JULY 1952

Journal

VOL. 44 • NO. 7

AMERICAN WATER WORKS ASSOCIATION

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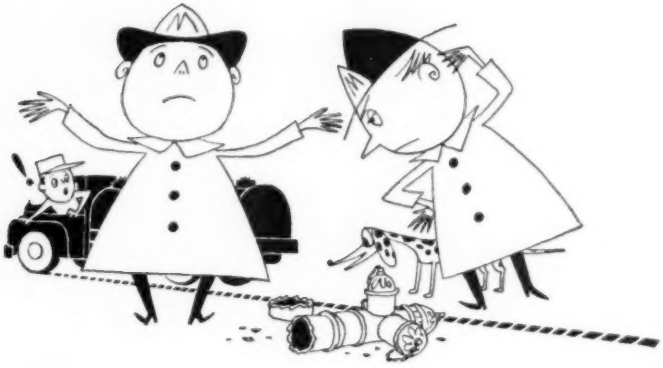
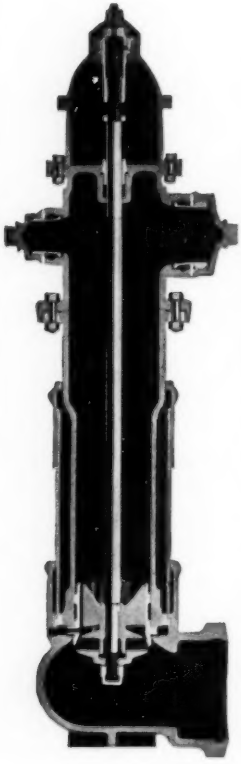
Broken hydrant cannot leak!





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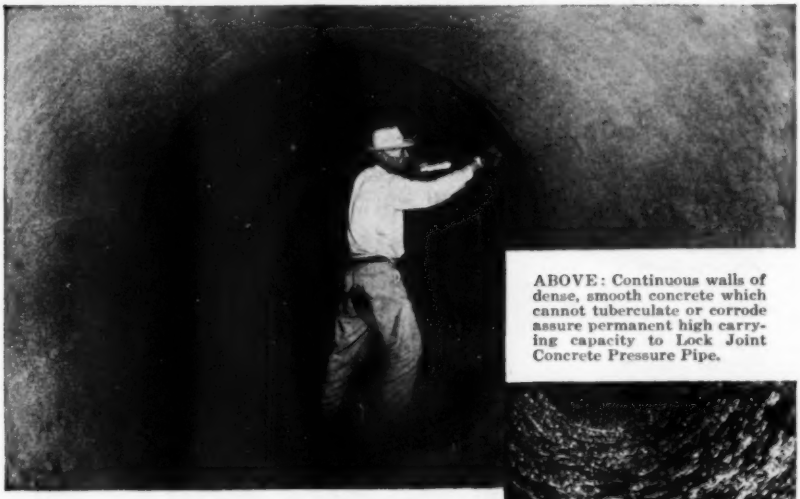
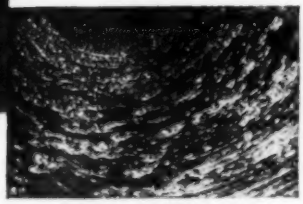


ABOVE: Continuous walls of dense, smooth concrete which cannot tuberculate or corrode assure permanent high carrying capacity to Lock Joint Concrete Pressure Pipe.



ABOVE: The tuberculated condition of this metallic pipe reduces its carrying capacity 50%.

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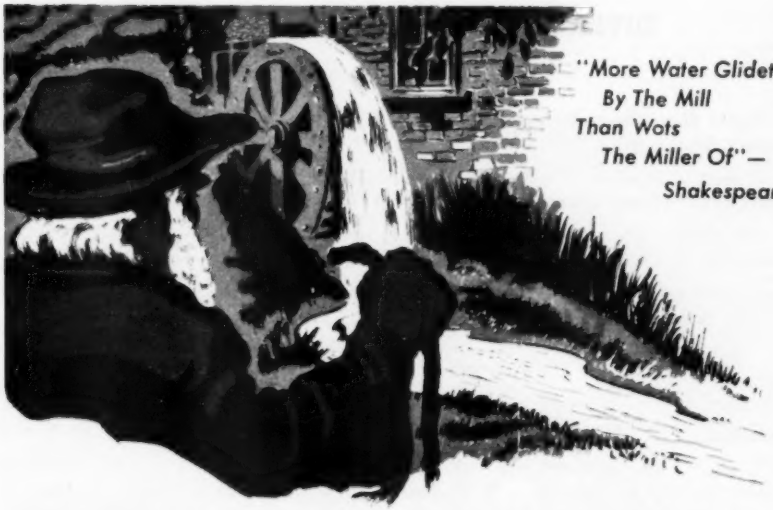

"More Water Glideth
By The Mill
Than Wots
The Miller Of"—
Shakespeare

THERE'S MORE WATER WASTED THAN YOU THINK...

A combined daily total of more than 2 BILLION gallons of water is being needlessly pumped by American water utilities.

Much of this daily waste or leakage could be controlled by meters and adequate meter maintenance. In addition, the amount of chlorine and coal used daily to treat and pump this water would be saved.

Reports from metered communities show that metering gives increased revenue, through closer accounting for water pumped. Records prove that one of the most effective ways to minimize water waste is metering—plus systematic inspection, testing and repair, especially of domestic meters neglected for years. The first step in reducing water waste, then, is to select the right type of meters—Trident Meters—the meters that keep their initial accuracy longest, and are easiest to repair when at long last repairs are needed.

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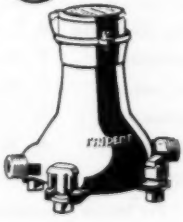

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FIELD TEST REPORT

New Plant Facilities Call For New Threshold Odor Survey

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a) Hydraulic jump, along with the lime for pH adjustment and activated silica.

b) The flocculation basin effluent.

c) The quick mix.

A threshold odor survey showed raw water entering the plant having a threshold odor value of 18 with an earthy-musty odor. Coagulation and subsequent settling reduced this odor concentration to 10 (a 44% reduction). The odor value remained at this level in the finished water.

Taste tests indicated that the palatable level of the water was equivalent to a threshold odor value of 6 on a finished water having a basic musty potato bin odor. In laboratory tests, Aqua Nuchar effectively reduced the tastes and odors to a palatable level.

A comparison of the various Aqua Nuchar grades also indicated that Aqua Nuchar A would seem to be the best grade for this plant to use both from a viewpoint of economy and odor removal. Laboratory tests conducted on the water from the hydraulic jump, after lime and activated silica application, with a threshold value of 18, demonstrated that Aqua Nuchar A gave a 72% odor reduction.

Laboratory tests and consideration of other plant treatment factors indicated that the use of Aqua Nuchar in the flocculation basin effluent would be the best point of application. At this point, the floc had already formed, and as a result, little of the Aqua Nuchar would be enmeshed in the floc, allowing greater efficiency for taste and odor adsorption. This point was also far enough ahead of the breakpoint application in the quick mix so that maximum efficiency would be obtained by the Aqua Nuchar as well as the chlorine.

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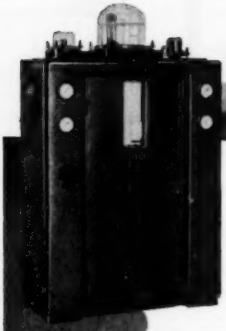

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Journal

AMERICAN WATER WORKS ASSOCIATION

VOL. 44 • JULY 1952 • NO. 7

A Program for Water Works

By Charles H. Capen

An address presented on May 8, 1952, at the Annual Conference, Kansas City, Mo., by Charles H. Capen, President, AWWA.

ASSUMPTION of the presidency of the Association leads one to a consideration of the elements in management of water supply systems which make for progress: intelligent planning; adequate margins of safety in operation; adequate revenues; cooperation with other users of water; participation in all water affairs; and a public relations sense.

The story of the city that lost a large industry because its taxes were too low, its government inefficient, its schools inferior, its recreation facilities too meager, and its travel facilities limited, can have its counterpart in a city where the water system has lacked planning, endured water shortages, and collected too little revenue. That city not only will fail to attract industry, but its sons and daughters will move to better-watered pastures.

Intelligent Planning

One of the most important aspects of water works operation is that of planning for future expansion. Planning involves many factors, including population trends, use trends, and impacts of sudden changes, such as those occurring during a war. All of these factors cannot be readily evaluated, and sometimes they cannot even be reasonably anticipated. The planner, therefore, must make the best estimate that he can.

Frontinus, who was in charge of the water supply of Rome nearly 2,000 years ago, was faced with the problem of estimating the future increase in population. Rome, at that time, used about 200 mgd, or sufficient for a present American city of nearly two million people. Today Rome probably uses much less water than it did twenty centuries ago.

The rapid and continuing growth of population in this country has seldom, if ever, been equaled in the history of the world. Will it continue? In our country, the East, particularly the Northeast, is not expanding as rapidly as the South and West. In some areas the saturation point of population has almost been reached, not because the city cannot absorb more people or expand, but because many people desire to live in less densely populated areas.

This tendency has been greatly accelerated by automobiles, highways, and other means of rapid transportation, and will probably continue.

The problem of supplying New York City with water, however, leads one to wonder how it is possible to meet all contingencies. New York City started to formulate plans for increased water facilities in the 1920's. A long suit in the Supreme Court and the lack of money as a result of the depression delayed the start of construction almost a decade. The development of additional supplies had just been started when World War II forced a cessation of the project. Completion is now scheduled, approximately, for 1956. The city suffered serious water shortages in 1949 and 1950, however.

The planners were not wrong by former concepts. Irving V. A. Huie, President of the New York Board of Water Supply, has said: "We must raise our sights from 25 years to 50 years." It was formerly considered good engineering economy to plan water works 25 years in advance. This axiom has been taught in educational institutions and can probably be found in textbooks. But the depression and World War II could not be foreseen and, even if they had been, no one could have guessed the ultimate effect on New York City's water supply. The concept of planning water works 50 years in advance, to overcome, if necessary, the unforeseen contingencies that arise on a national or international scale, without relationship to the growth or needs of an individual community, is somewhat unusual.

Some of the mushroom growths in the South and West present a perplexing problem to the water works planner who wants to get the most for his dollar in additional facilities. Many cities in the northeastern part of this country went through the same sort of metamorphosis. Water consumption in the Nineteenth Century was far less per capita than it is now, however.

It may be necessary to accept a dual standard whereby a long period would be established for water planning in those areas in which the rate of growth is diminishing, and a different, shorter period for the areas in which growth is still rapid. A 50-year period might be economical in one area, and a 25-year period in another. The longer span could be applied to older cities, particularly those communities in which piecemeal development may be safely relied upon. When it is impracticable to develop water works properly except on a large scale, it may be necessary to employ entirely different periods. In sections of the country where the rate of expansion is known to be variable, a shorter period may be adopted so that facilities will not be developed that may never be needed. The "Blueprint Now" program instituted by AWWA a few years ago has been a forward-looking step. It must be augmented at the local level by additional long-range planning.

Safety Margins

For many years, structural engineers have used factors of safety on the order of four—designing for four times the loads that might reasonably be expected. The procedure is common in most construction practice, and even homes are built with "expansion attics." Only in hydraulics are safety margins practically eliminated—the result of a most unrealistic attitude, which must be overcome.

William W. Brush has proposed a safety storage margin of 25 per cent in the reservoirs operated by New York

City in order to meet emergency conditions. The wisdom of this safety factor was amply demonstrated in 1949 and 1950. Recently in New Jersey, a group of water engineers proposed that instead of a 25-per cent storage margin —which would give an increase in yield of less than 25 per cent—an overall safe yield margin of 25 per cent be provided. This proposal is an effort to overcome the effects of unusual events, and is closely related to proper planning, as well as to efforts to overcome pinch-penny attitudes.

Adequate Revenue

Neither the lack of safety margins in hydraulics nor pinch-penny attitudes can be overcome without sufficient funds. That water is cheaper than dirt has been emphasized many times. It seems, however, that water works too often do not have enough capital to proceed with a major improvement program until the situation becomes little short of desperate.

The reason for this condition is that, fundamentally, water is sold too cheaply. The late William Chester Morse of Seattle expounded the theory of charging a good round price for water. When needed improvements were required, there was a sufficient sum in reserve to finance them. In addition, he always arranged for funds to be available to help out the city treasury when a little bolstering was desired. Many do not approve the latter procedure, but at least it helped to take criticism away from the water department when rate increases were desired, and substantiated sufficient rates.

Privately owned companies cannot take advantage of such procedures, and the burden of foreseeing the future is much greater for them. Like their colleagues in publicly owned water works, they must have rates adequate to sustain their needs.

Actually, many water works are existing in a "fool's paradise" today. Consumption has continued to increase since 1934. Inadequate rate structures have supported present needs only because most facilities have been taxed almost to the limit, and income has been correspondingly greater than ever before. Some comparisons will show how other utilities have fared during the same period.

In New Jersey reliable statistics are available for nearly 250 water systems. A tabulation of their statistics shows that in the last two decades, water revenues for both privately and publicly owned systems have increased approximately 60 per cent. During the same period and in the same area, electric revenues have increased 115 per cent, gas revenues 75 per cent, and telephone revenues 220 per cent. Expansion of some of these facilities—notably telephones—has been greater than has the expansion of water systems. A review of rate changes, however, gives additional evidence that water charges are lagging. Although gas, electric, and telephone utilities are not strictly comparable to water works, the increase in income of these utilities shows clearly that they have gone far ahead of water, probably because of greater utilization and greater increases in rates. The 5-cent telephone call appears definitely to be on its way out, at least in some areas, and the 5-cent transportation fare disappeared in many places long ago.

If an increase in water rates of similar magnitude were suggested, there would probably be an outpouring of objections at the start, but gradually, these objections would subside. Water

works men have either failed to recognize fully the effect of changing times, or have been unable or unwilling to do much about it. Whatever the cause, the water works profession must determine what water is really worth, and, if rates are insufficient to insure adequate income in the future, they must act to change them.

One of the obvious benefits of adequate rates would be adequate pay for water works personnel. When a man who has successfully conducted the affairs of a sizable water works for many years finds it profitable to join a private industry, his colleagues in the water works profession cannot help but wish him well, while, at the same time, lamenting the situation that makes it necessary for him to change.

Perhaps the most startling story of inadequate income is that told by John S. Telfair Jr. (1), who cited the water operator whose salary remained static —except for the period in the depression when it ceased altogether—at $125 per month from approximately 1927 to 1948. It was then increased to $175 per month. This is a sad commentary on the conduct of water works affairs.

Cooperation

Figures published by the U.S. Geological Survey for 1950 show that more than 1,100 bil gal per day (bgd) of water are used for producing power, the largest purpose for which water is employed. Of course, this figure included a number of multiple uses of water in its travel downstream, and represents a nonconsumptive use. Irrigation took nearly 80 bgd, the next largest requirement. Irrigation frequently results in a complete diversion from a water source or stream. The amount returned varies greatly and may be difficult to determine.

Estimates of industrial use vary between 20 and 80 bgd. The higher figure includes large amounts of brackish water and condenser water, and, therefore, represents use that is not completely consumptive. Even assuming the minimum figure of 20 bgd, it is apparent that industry consumes more water than the entire municipal use of 14 bgd. Inasmuch as approximately one-half of all the water sold through public water systems is also delivered to industry, it can be seen that the gross needs for water to keep the wheels turning in factories are enormous.

The water works man becomes extremely angry when an industry empties polluting material upstream from the water works intake, but he does not always cooperate with industry, or encourage mutual studies of monthly use and bills. It would seem wise to make the acquaintance of the large industrial users, so that common problems can be solved together rather than in opposition to each other. According to one study (2), industry has increased its use 36 per cent in the decade between 1940 and 1950. The explosive stage in the consumptive use of water may have been reached. The water works profession must make a determined effort to see that there is enough water for existence and continued prosperity.

A Public Relations Sense

Getting along with the public has been so well urged by now that it is not necessary to dwell upon this subject. There is one aspect of public relations, however—one segment of the public—which has received little attention. And this is the relationship with representatives of manufacturers. Many water works designers and operators

rely upon them as messengers of information, from whom can be obtained news of advances in the field of planning and construction. To think of them only as salesmen is to overlook the technical training and experience which has made them travelling storehouses of ideas.

Sometimes it is not easy to tell a capable representative that he will not receive an order, but often he will prefer being told honestly, instead of being left to find out from other sources.

Participation in Water Affairs

The quantity use figures given previously are evidence that water for public supplies is rapidly being relegated to a position of poor fourth. Nevertheless, public water supply is considered the "Number One Utility." Is it? Some people think not. People in the water works industry must take an active part in affairs that will keep them in close contact with all the fields of water use.

Recently a state which has large agricultural interests passed a law requiring the governor to appoint 24 agriculturalists to dispense the water benefits of the state. The water operators had no one sufficiently close to those in power to press their just claims for representation. The author does not suggest that all water men should go into politics. Rather, they should actively cultivate those acquaintances which will enable them to express proper viewpoints at the correct time. Unless they do, the future of water supply, as it is known today, will be one of continuously increasing frustration. The water works industry owes it to the people it serves to see that their interests are properly safeguarded.

References

1. Telfair, John S. Jr. The Present Status of Public Water Systems in Florida. Jour. AWWA, **42**:416 (Apr. 1950).
2. *Water in Industry.* National Assn. of Manufacturers & The Conservation Foundation, New York (1950).

So-called Electrical and Catalytic Treatment of Water for Boilers

By Rolf Eliassen and Herbert H. Uhlig

A paper presented on May 5, 1952, at the Annual Conference, Kansas City, Mo., by Rolf Eliassen, Prof. of San. Eng., and Herbert H. Uhlig, Assoc. Prof. of Metallurgy, both of Massachusetts Institute of Technology, Cambridge, Mass.

CONTROL your scale electrically"; "Just plug it in"; and "Costs no more than an electric clock to operate!" These are headings on an advertisement for a so-called electric scale-control unit. Simplicity and economy have long been the lures which attract so many operating engineers when purchasing equipment for use in boiler water treatment. A host of simple gadgets for conditioning of water is flooding the market again. Riding on the crest of the electronic age, manufacturers are making all sorts of claims for their little wonder-packages which can be connected into the water line and, by a little current from internal galvanic action between plates of two dissimilar metals, an external applied current, or some mysterious catalytic action, answer all of the problems of boiler feedwater treatment—and many other problems as well. Promoters are claiming that some of these simple cure-all devices will eliminate operating difficulties arising from scale, corrosion, turbidity, algae, and bacteria. Frequently, engineers and operators have neglected to ask whether equipment really works as claimed and whether it is based on sound scientific principles.

Members of the water works profession should not be taken in by these extraordinary claims. The excellent research that has been accomplished and published in technical journals establishing the basic principles is not to be swept aside and circumvented "just like magic," as one advertisement states.

The water works engineer, when approached by a salesman for the magic type of water treatment equipment, should:

1. Subject the performance claims of the manufacturer to critical analysis and experimental evaluation.
2. Examine the pseudoscientific terminology which usually forms part of the advertising literature.
3. Compare the operating facts of the apparatus with known scientific principles.

Manufacturers' Claims

The manufacturers' extraordinary claims are all directed toward eliminating well-known troublesome problems in the fields of scale and corrosion control. Most of the units claim to control scale with no addition of chemicals, merely by the application of a small electric current measured in microamperes or by the introduction of some mysterious catalyst. Some manufacturers throw in corrosion control for

good measure. One manufacturer makes the following claims for the addition of a little catalytic tank to the water line:

Bacteria

"Bacteria in potable water has * always been a major problem for city water dispensing authorities. The general water treating process currently being used merely kills the bacteria, but does not kill the larvae. Larvae finds a natural breeding ground in the deposits of scale, some algae, humus, and all other deposits from the source of the water plant through the carriers to the consumers. By the use of water through [this process] and the elimination of scale, humus, some algae, etc., the larvae must cease to exist and thus reduce, if not eliminate, the bacteria."

The Facts

Bacteria do not have larvae nor do they exist in the larval stage. The whole statement indicates that the manufacturer knows very little about the problems of the water works engineer.

Odors

"Odors are generally created by deposits in the water carriers, which deposits take the forms of scale, some types of algae, humus, etc., and by the introduction of chlorine for combatting the bacteria, a chemical reaction occurs. The combination of the chlorine with the humus or certain algae creates a phenol that increases the unpleasant odors. Through the use of [this process], the humus, scales, and some algae are removed and thus the odors decrease."

* No attempt has been made to correct the grammar in the manufacturers' literature.

The Facts

Most odors are caused by substances present in the original water supply, not from pipeline deposits. Chlorine reactions do not create phenols.

Turbidity

"By the dispersion created by [this process], the elements that give water its turbidity having been dispersed, the water takes on a crystal-clear optical appearance."

The Facts

If mineral substances could be dispersed by a long-lasting catalyst (a small tank may last 6 months) all coagulation, settling, and filtration problems could be ended. This claim is absurd.

Scale

"As to the already existing scale and corrosion, these are all formed by impurities of the water and are paramagnetic elements. The activated water created by [this process] activates the layer of scale with which it first makes contact and causes a microscopic swelling of these layers. The enlarged layer created by this swelling process is then subjected to a process of dispersion and gradually depolymerizes into the flow of water. It must be understood that this swelling process, layer by layer, and the resultant elimination is a slow process and each layer receives the same treatment until all of the scale is removed."

The Facts

So-called depolymerization is only a fancy term for the return of calcium carbonate and other mineral crystals into solution. This return to solution may be caused by acids present in the

water, such as carbonic acid, or by added chemicals. As the installation of these depolymerization units is usually accompanied by the cessation of chemical addition to boiler water, a different chemical balance presents itself. But the chemicals were added for a purpose—to precipitate incrustants as a sludge to be blown off, and to prevent corrosion. Without these chemicals, boiler failure may result.

Corrosion

"By removing the deposits of iron oxide, the galvanic current that it creates is reduced in direct proportion to the size of the deposit of the iron oxide and thus reduces the corrosion. The fact that the elements are dispersed by [this process] in itself reduces their corrosive tendencies."

The Facts

Water works experience in the cleaning of tuberculated water mains has shown that, with corrosive waters, the removal of tubercles and rust exposes fresh iron surfaces, increases the overall rate of corrosion, and stimulates further tuberculation. Deposits of iron oxide are not necessarily the prime cause of corrosion—they are the result of iron lost from the pipe by the action of corrosion, and usually reduce the rate of attack.

Catalysis

"It must be understood at the outset that [this process] does not in any way change the chemical structure of water. The catalytic action is that of setting up an increase of the molecular magnetic susceptibility of water, creating a great dispersion of the elements in water that have an affinity that cause scale, rust, and corrosion." This dispersion is explained at great length and the manufacturer bases all conclusions on the statement that, "the catalytic process produces a variable magnetic field in the water passing through the —— apparatus, and this field has the power of converting unstable parahydrogen to orthohydrogen."

The Facts

These complex pseudoscientific claims fall down because the conversion of parahydrogen to orthohydrogen does not apply to hydrogen in combination with oxygen as in water, but only when hydrogen exists as a diatomic molecule (H_2). Even with H_2, the reaction is a second order effect related to the nonequilibrium state of nuclear spins when hydrogen is brought from a very low temperature to room temperature. In addition, magnetic fields have doubtful influence on scaling, corrosion, or dispersion of salts in water.

The most ridiculous of this company's claims is set forth in the statement: "Periodically an inhibiting action must be provided for, to counter the accelerative catalytic action. This inhibiting action suppresses the magnetic field in the —— apparatus. The active, catalytic period must last for two consecutive days, and the subsequent inhibiting period for five successive days." In other words, water passes through for only two days a week: the remainder of the week the apparatus must be drained and vented to the air.

Additional Pseudoscientific Terminology

1. One manufacturer explains an electrical gadget for water conditioning in these terms:

"[This unit] creates that neutral corpuscle of electricity creating physical change. When an atom looses one or more of its electrons, it becomes incomplete and immediately joins an-

other of like or different material in order to complete its circle of electrons. [The unit] makes inert those elements that cause corrosion or destruction. [The unit] makes positive those elements that become inert under heat, pressure and cold, thus eliminating scale formation as these particles remain minute and in solution."

The Facts

No "neutral corpuscle of electricity" is created in galvanic circuits or by catalysis. Electrons flowing through a wire are negatively charged. An atom in solution minus an electron does not immediately join another atom or ion, but remains positively charged as an ion, such as Na^+. The selectivity of making some elements inert and some positive is double-talk, particularly as scale is made up of compounds of several elements. These compounds precipitate when the solution becomes saturated. Saturation occurs as steam is generated and the solution becomes more concentrated. Certain organic colloids are used as chemical feeds to produce a soft sludge, but precipitation still takes place.

2. Another manufacturer, in his description of a gadget employing radiation instead of electricity states that his particular equipment employs "the use of hermetically sealed cylinders which contain a specially prepared formula. This formula emanates an energy or potential which can be likened to, but not compared with, heat waves. This very absorbable radiation causes an alteration to the normal physical characteristics of the mineral deposits. This radiation imparts a particular form of molecular energy to the water, producing a state of activation of the molecules or molecular aggregates. There is a transference of this energy from the water to the scale, causing changes in the surface electrical condition of the scale particles themselves, and between the particles and the metal surfaces of the boiler."

In attempting to explain these mysterious effects, the manufacturer further states: "Chemically, the water treated by [this process] is exactly the same at the time that it enters the preheater or boiler as it was when it was raw untreated water—thus there is no chemical theory. [The process] neither adds nor removes any ions or salts; it merely 'disturbs' the balance of those ions or salts present through the use of a molecular energy (or through an ionic activation) imparted to the water. In other words, [this] is an 'ionic' not a 'chemical' process, and we are thus able to accomplish 'physically' (without theory) what has been attempted for years in following a 'chemical theory.' "

The Facts

This ecstatic outpouring of mumbo jumbo speaks for itself. Chemical processes and ionic processes cannot be separated. The standard chemicals used in boiler water treatment provide ions, such as PO_4^{---}, which react with other ions, such as Ca^{++} and Mg^{++}, to produce insoluble compounds which thus remove scale-forming minerals as sludge.

3. Another supplier of an electrical device claims: "The [process] unit makes no chemical change in the water, creating instead a purely physical change. Consequently, a chemical analysis taken before and after the water passes through a [process] cylinder will be the same. Nothing is taken out of the water, nor is anything added to it by [the unit's] operation. A clearly defined cream line develops in 'regular'

milk. In homogenized milk the cream is just as truly present, but it is controlled. Similarly [process] units control the separation of particles which would otherwise build up scale on metal surfaces."

The Facts

The statement, "Nothing is taken out of the water, nor is anything added" is undoubtedly true.

4. The claims which are noted here are typical of manufacturers who promote this kind of equipment for the control of scale. One manufacturer made such startling claims as:

"Just like magic—conditions your water supply—electrically, no chemicals or compounds required. . . . Any industry or institution can now be assured of a regular flow of uniformly pure water free from corrosive acids, plant, or mineral matter. Most water contains various salts in solution or in a colloidal state. The [process] conditioner electrically charges these scale-forming, acid, and corrosive substances so that they are repellent to each other as well as the metal surfaces of all equipment, water, and steam lines. Algae and foreign growths are eliminated. This boon for industry is achieved easily, quickly and economically through the magic electrodes of [this process]."

Perhaps the most extraordinary claims are those made by the manufacturer of the same kind of gadget employing a small impressed current between an anode and a cathode. With this apparatus, some of the sweeping claims include: "Does away with boiler compounds. Prevents scale formation in boilers and boiler systems. Prevents corrosion by eliminating its cause. Prevents foaming, priming, bumping. Prevents embrittlement and cracking."

This promoter goes even further in claiming miracles for household water units:

"Makes bathing water positive to the body.

"Makes cooking easy, for all flavors are natural, there being no radicals in the water to hinder correct emulsions by natural processes.

"Four-fifths of all foods are water, therefore you eat less as you have the perfect base.

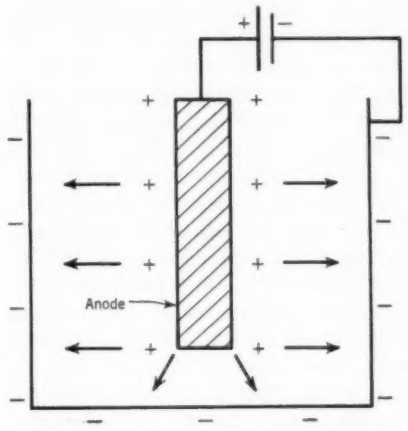

Fig. 1. True Cathodic Protection of Water Tank

The tank wall and bottom form the cathode and are protected by current over the entire surface.

"Aches, pains, sour-stomach, indigestion, and the ailments come from pressure or excess radicals; drink pure [process] treated water for one week, it will tell you the story, regarding Natural, Physical Rehabilitation, Internal or External. . . . After using [process] treated water for ten days, then, you feel distressed, you better see your doctor, for you are beyond natural rehabilitation due to some extreme pressure."

The Facts

The reader may judge the facts.

Claims of all sorts could be given *ad infinitum*, as the zeal of the medicine men apparently knows no bounds. Experimental work conducted on a scientific basis, time-consuming though

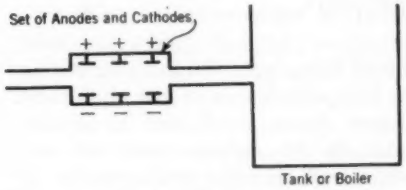

Fig. 2. So-called Electrical Treatment Units

The set of anodes and cathodes is remote from the tank or boiler. There is no flow of current through the water to the walls of the tank or boiler.

it is, often is required to uncover the fallacies in claims by questionable promoters. But many times the claims are so wild that experiments would be almost superfluous. Promoters in this class almost always resort to testimonial letters from "satisfied" users of their equipment. In most instances, the letter writers are not technically trained and are easily deluded into thinking they have derived benefit, at least up to a point. It is well to beware of these testimonial letters unless the source is well known.

The real answer to the boiler water problem comes from engineering experiments of the kind conducted by Hurley and coworkers (1), who observed scaling in low-pressure boilers at various stations in England, with and without electrical treatment of the feedwater. They concluded that the differences in observed scale deposits in various boilers "do not appear to be associated in any way with the electrical treatment of the feedwater, and they [the differences] are equally apparent whether electrical treatment is used or not."

The authors conducted a brief correspondence with two American manufacturers, one of electrical and one of catalytic devices, but received, in return, more claims, testimonials, and evasive answers. The engineering data that were sought were not supplied, nor was there anything to indicate that data of this kind had at any time been obtained by the companies.

Scientific Principles

Years of research have established the facts of scale formation (2). As water evaporates in the boiler to form steam, the mineral salts in the water become more concentrated. When the solution becomes saturated with any particular mineral, crystals of the salt begin forming at the point of greatest concentration or highest alkalinity—usually at the heat-exchange surface. No amount of mysterious dispersion by small so-called electrical forces will prevent this crystallization. The only means of prevention is to treat the feedwater by adding chemicals, at times both inorganic and organic, to the water to remove the scale-forming substances in the form of a soft sludge, either ahead of the boiler or in the boiler.

While in solution, the mineral salts exist as ions—positive ions such as Ca^{++}, Mg^{++}, and Na^{+}, and negative ions such as HCO_3^{-}, SO_4^{--}, and Cl^{-}. Small galvanic currents will not add or subtract total charges from the solution. Ionization is a function of known physical and chemical factors and not minute currents flowing in some mysterious manner in one small part of a system. Ionization occurs immediately when a

salt is dissolved, and no electric current will do any more dispersing or ionizing as claimed.

Corrosion is an electrochemical phenomenon, the proof and understanding of which are based on much sound research. Basically, galvanic cells form on metallic surfaces. Depending on a number of factors, anodes and cathodes occur at many places on the surfaces of pipes and boilers. Loss of iron occurs at the anodes according to the reaction:

$$Fe \rightarrow Fe^{++} + 2 \text{ electrons} \quad \text{(Anode)}$$

To stop this reaction by a countercurrent is possible and is accomplished by the process known as cathodic protection. This process has been applied successfully to water tanks, to the protection of thousands of miles of buried pipelines, and to other equipment. It employs an impressed direct current using a set of auxiliary anodes, or a galvanic current derived from sacrificial anodes (Mg), placed in such a way that the current reaches every square inch of exposed metal surface being protected. It is difficult to accomplish this protection inside pipes and boilers because the anodes would have to be installed inside each tube.

Cathodic protection is entirely different from the so-called electrical apparatus for water conditioning which employs a small current between anodes and cathodes located at a considerable distance from the boiler or pipe surface being purportedly protected. Figures 1 and 2 show a comparison of the electrolytic effects. To be protective, the current must reach the corroding surface and must be adequate to suppress the corrosion reaction. No claim is made for the control of scale by the legitimate process of cathodic protection.

Summary

A study has been made of the advertising literature of some of the manufacturers of so-called electrical and catalytic methods for the control of scale in boilers. Extravagant claims have been analyzed on the basis of scientific facts. The prospective purchaser of equipment for which mysterious or magical claims are made should investigate the fundamental basis for performance of the equipment. Unless claims for it can be substantiated by an analysis based on well-established scientific principles, or by adequate laboratory or engineering experiments, the purchaser should be skeptical.

Many frauds are being perpetrated on an unknowing and gullible public. The water works profession has reached a high state of development through the appreciation of sound principles of science and engineering because it has subjected each new proposal to a critical scientific study. Many new and sometimes radical changes have been introduced, but they have always had a sound background for acceptance. Fraudulent devices and processes come and go, necessitating vigilance on the part of engineers who should be willing to accept new ideas based on scientific facts and engineering performance, but who should equally reject proposals, no matter how attractive, supported, at best, by testimonials.

References

1. HURLEY, INGLESON, ET AL. Electrical Treatment of Boiler Feed Water. Jour. Inst. Wtr. Engrs., 5:686 (Nov. 1951).
2. *Water Quality and Treatment.* Am. Water Works Assn., New York (2nd ed., 1950).

Instrumentation and Methods for Testing Radioactive Contamination in Water

Task Group Report

A preliminary report by Task Group E5W-12, Instrumentation and Methods for Testing Radioactive Contamination in Water, presented on May 5, 1952, at the Annual Conference, Kansas City, Mo., by H. H. Gerstein, Chairman, Chief Filtration Chemist, Water Purification Div., Chicago, Ill. The other members of the Task Group are Ray L. Derby, Roy J. Morton, Harold E. Pearson, H. Gladys Swope, and Frank S. Taylor, with William F. Bale, Robert L. Butenhoff, and L. R. Setter acting as consultants.

THE atomic age presents the problem of possible harmful radioactive contamination of water supplies as a result either of enemy action by atomic bombing or radiological warfare or peacetime disposal of atomic wastes. Radioactive wastes can originate from the atomic piles that are used in the manufacture of atomic products, from the use of radioactive isotopes for medical treatment, research, and various industrial applications, and probably, in the foreseeable future, from the operation of nuclear power plants. It is important, therefore, that those responsible for the safe quality of water supplies have reliable and practical methods of testing for the presence and amount of radioactivity in water and of determining the potability of water supplies suspected of having received radioactive contamination.

Radioactivity is a new potential contaminant of water supplies. It is necessary that the water works profession learn the properties of the different radioactive contaminants, the safe tolerance levels of activity in water, and the various methods for detecting radioactivity in water. The profession should also be aware of the potentialities for using radioactive materials for research in the water works field. Water works technicians can learn to make full use of radioisotopes and radiological techniques in conducting development and research in their field.

Definitions

Many special terms are used in radioactive contamination studies. The terms which pertain to testing for radioactivity in water include:

Radioactivity. An atom is radioactive if its nucleus disintegrates spontaneously, thereby emitting ionizing particles or radiations. The ionizing particles or radiations emitted may be in the form of alpha or beta particles or gamma rays. Alpha particles are high speed helium nuclei which expend their energy quickly and hence have very short ranges of penetration. Beta particles (beta rays) are high speed electrons, the most energetic of which may penetrate $\frac{1}{4}$ in. of wood. Gamma rays are electromagnetic radiations of

the same nature as X-rays, and are very penetrating.

Half-life. A half-life is the time required for the activity of a given quantity of radioactive material to decay to one half the initial value.

Ionization. Ionization is the act or result of any process by which a neutral atom acquires a charge but most frequently by the liberation of one or more electrons.

Roentgen (r). The roentgen is a measure of the amount of radiation dosage and hence is a measure of the hazard to living organisms. It is defined as the quantity of X-ray or gamma radiation which produces 1 electrostatic unit of charge per ml of standard air exposed to the radiations. A milliroentgen (*mr*) is one-thousandth of 1 r.

Curie. The curie is a measure of the quantity of radioactivity which produces 3.7×10^{10} (37 billion) atomic disintegrations per sec. A millicurie (*mc*) is one-thousandth of 1 curie, and a microcurie (μc) is one-millionth of 1 curie. The microcurie is the unit of measurement most commonly used for recording radioactivity in water.

Selected references explaining the elements of radioactivity for the layman will be helpful to water works technicians who plan to test for radioactivity in water (1–22).

Physiological Effect

Nuclear particles or radiations affect living tissues by ionizing the exposed cells, resulting in chemical changes which damage the tissues. The nature and intensity of the injury depends on the penetration effect, intensity, and energy of the radiation, the length of time the tissue is exposed to the radiation, and the kind of tissue.

The human body is always exposed to small amounts of radiation from decay of extremely small amounts of the radioactive elements naturally present in the earth and water, and from cosmic rays which penetrate from the outer atmosphere. These radiations may vary in intensity depending on the altitude of the location and the possible presence of deposits of radioactive ores. The amount of natural radiation to which a person is exposed during his lifetime is very small and is not known to be harmful.

All natural waters contain minute amounts of radioactive elements in quantities which are difficult to measure except by special techniques and instruments. The radioactive elements most likely to be found in natural waters in trace quantities are uranium, radium^{226}, potassium^{40}, and carbon^{14}. This type of radioactivity is called the natural radioactive background of a water. Some spring waters contain much radioactivity and are used daily for drinking purposes without, as far as is known, noticeable effect on the consumers.

The half-lives of the radioactive elements vary from a fraction of a sec-

TABLE 1

Permissible Emergency Levels for Radioactive Contamination in Drinking Water (17)*

Consumption Period *days*	Safe Level *μc per ml*	Acceptable Risk Level *μc per ml*
Maximum Beta-Activity Level		
10	3.5×10^{-3}	9×10^{-2}
30	1.1×10^{-3}	3×10^{-2}
Maximum Alpha-Activity Level		
10	2×10^{-4}	5×10^{-3}
30	6.7×10^{-5}	1.7×10^{-3}

* For period immediately following atomic explosion.

ond to many thousands of years. Some of the radioactive elements, when ingested by the human system, are excreted quickly, and radiation damage is thereby limited, whereas others may concentrate in a particular part of the body, such as the bones or certain glands, and cause long-period radiation exposure and damage. A radioactive element that is short-lived and is excreted quickly can be tolerated by the tissues without much damage even though taken in fairly high dosages, whereas a long-lived radioactive element that accumulates in the bones can be tolerated only in extremely low

TABLE 2

Disintegrations and Radioactivity Concentrations

Radioactivity Concentration *μc per ml*	Nuclear Disintegrations *no. per min per ml*
1	2,220,000
10^{-1}	222,000
10^{-2}	22,200
10^{-3}	2,220
10^{-4}	222
10^{-5}	22.2
10^{-6}	2.2
10^{-7}	0.22
9×10^{-2}	199,800

concentrations. Radium, for instance, has a half-life of 1,600 years and is also a bone-seeker, and, consequently, is extremely dangerous even in minute quantities.

Radioactive contamination of waters is usually measured in microcuries per milliliter. The accepted maximum concentration level for unidentified radioactive contaminants in drinking water for long periods of use—25 to 30 years—is 0.0000001 μc per ml (10^{-7} μc per ml) except in the unusual event that appreciable amounts of radium[226] are suspected.

It has been suggested that during a civilian defense emergency, if no better supply can be obtained, drinking water with approximately 0.09 μc per ml of beta-gamma activity may be consumed for a period of ten days without appreciable harm to the consumer and water with one-third of this activity concentration, 0.03 μc per ml, can be consumed for a period of thirty days without appreciable harm. These emergency values are for fission products within the first few days following an atomic explosion, not for aged materials or long-lived radioactive products. The permissible emergency levels for radioactive contamination of drinking water after an atomic bombing suggested by the Office of Civilian Defense are given in Table 1.

Most of the measurements of radioactivity in water fall within the range from 10^{-7} to 10^{-1} μc per ml (0.0000001 to 0.1 μc per ml). Table 2 gives the number of disintegrations which correspond to certain radioactivity concentrations.

Instrumentation

All instruments for detection of radiation depend on the ionization effect produced by the alpha, beta, or gamma rays resulting from nuclear disintegration of the radioactive atom. The most commonly used instruments for testing for radioactivity are the ionization chamber, the Geiger-Muller counter, and the proportional counter. The ionization chamber measures continuously the ionization effect of the radiation entering the instrument. In the Geiger-Muller and proportional counter, however, each ionization pulse produced by the radiations is amplified electronically and is either recorded as a click in an earphone, registered on a mechanical counter, or in-

dicated by the needle of a meter dial as counts per unit of time.

Theoretically, the meters should register each radiation produced by nuclear disintegrations as an individual count. Because of many complicating factors, however, only a small percentage of the radiations are actually counted. Special counters are designed to be more sensitive to alpha, to beta, or to gamma rays.

Two of the most important factors responsible for low counting efficiency are:

1. Absorption of the radiations by the sample itself or by the wall of the meter detecting device. Alpha particles are the least penetrating of the radiations and are most easily absorbed. Beta rays are absorbed to a lesser extent and gamma rays are the most penetrating and least absorbed.

2. The radiations are emitted in all directions. Only those radiations which are emitted in the direction of the meter detector are counted. The radiations emitted in other directions are missed unless they are deflected and bounce back toward the detector element.

In a particular measurement situation, the percentage of the actual total nuclear disintegrations of the sample that is measured as radiation counts by the instrument represents the overall counting efficiency, frequently called the geometry of the instrument. When the geometry of the testing procedure is established, it is possible to calculate the nuclear disintegrations and, from this data, activity present may be measured.

A low counting efficiency usually results if the radioactivity measurements are made by placing the detecting element of the meter over the surface of the sample or by submerging the detecting element in the water. It is possible to improve the geometry and the efficiency of the counting by evaporating a portion of the water sample on a small metal disk called a planchet, thus depositing the radioactive material in a thin film.

Radioactive water contamination in the range of permissible emergency levels can be tested by the simpler techniques and instrumentation, whereas water with activity at the long-term tolerance level requires much more sensitive instrumentation and techniques.

The counting problem is further complicated by the background counts of the instruments. These counts occur continuously even in the absence of radioactive samples, mainly because of cosmic rays and the natural radioactivity in the materials from which the instruments are constructed. A typical Geiger-Muller counter may have a background count range of 20 to 120 counts per min, depending upon the sensitivity of the counter, and the shielding of the detecting elements. It is difficult to obtain accurate counts of samples in which the radioactivity count is less than the background count. It is impractical, therefore, to count 0.22 disintegrations per minute for water having a radioactivity of 10^{-7} μc per ml with an instrument having a background of, for example, 50 counts per min unless some method of concentrating the sample is employed.

If a liter of water having radioactivity of 10^{-7} μc per ml is evaporated in a thin layer on a planchet, it is possible to concentrate radioactivity having 220 disintegrations per minute on the planchet. Because of the absorption of the radiations by the dissolved solids

which are also deposited on the planchet when the water is evaporated, and because of the geometry of the instrument, however, only a portion of these disintegrations are registered as counts. The measurement of natural background radioactivity in water in the range of 10^{-8} to 10^{-9} μc per ml is even more difficult. It may be necessary to measure radioactivity in this range by special radiochemistry techniques and instrumentation which are too complex for most water works laboratories.

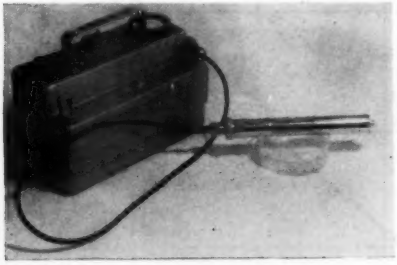

Fig 1. Portable Geiger-Muller Beta-Gamma Meter

Instrument is calibrated in milliroentgens per hour and is used primarily for emergency field surveys for radioactivity.

Recommended Testing Methods

The Task Group feels that, from a practical standpoint, testing procedures and instrumentation for detecting radioactive contamination should be as simple as possible and should require only minimum training of average water works technicians. It is especially important that the procedures for testing the potability of drinking water in the emergency level range suggested by the Office of Civilian Defense be simple. The Task Group has studied the range of sensitivity of various types of instrumentation and methods of testing. There is much to learn, however, and it is not the intent of the Task Group to standardize or oversimplify the problems. The methods and instrumentation for testing for radioactivity in water which the Task Group recommends may be summarized under four classifications:

Method 1. Geiger-Muller Survey

Application. For rapid field surveys during civilian defense emergencies to determine whether drinking water contaminated with radioactivity is within the permissible emergency levels.

Instrument. Portable Geiger-Muller, thin side-wall tube, beta-gamma survey meter calibrated in milliroentgens per hour —0.2, 2, and 20 mr for full scale range (Fig. 1).

Cost of Instrument. Approximately $200 to $300.

Detection Sensitivity. Sample of 150 ml—10^{-3} to 1 μc per ml (Fig. 2). The instrument is calibrated in milliroentgens per hour against gamma radiations. Figure 2 shows the relationship between microcuries per milliliter activity in 150 ml of water against milliroentgen per hour readings on the instrument scale. It should be understood that no direct relationship exists between milliroentgens per hour and microcuries per milliliter.

Testing Procedure. Methods for testing and for preparing standards are given by Hursh, Zizzo, and Dahl (17). It is probable that the standards will be available for purchase from instrument manufacturers. An 8-oz, 150-ml, open-top salve box, $3\frac{3}{4}$ in. in diameter, is required as a water container. Two standards are required: Standard A—radioactivity equivalent to 3.5×10^{-3}

μc per ml, 10-day safe emergency level; Standard B—radioactivity equivalent to 9×10^{-2} μc per ml, 10-day acceptable risk emergency level. To monitor the contaminated water:

1. Invert lid of container to expose Standard A deposited on inner flat surface.

2. Turn on survey meter. Note background reading.

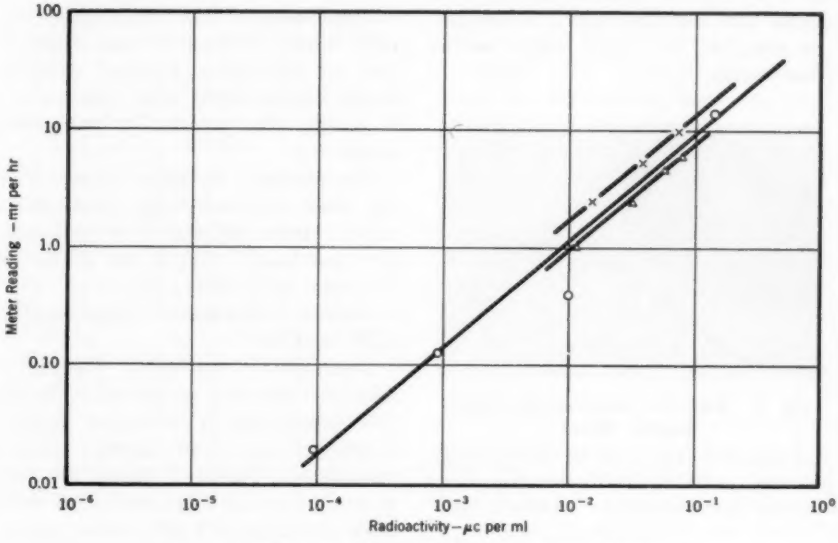

Fig. 2. Calibration of Geiger-Muller Survey Meter

The water used for calibration was seeded with various amounts of radioactive isotopes which are indicated by the symbols on the figure.

○—*Strontium*^{90}*, Chicago South Dist. Filtration Plant Data*
×—*Phosphorus*^{32}*, Hursh, Zizzo, and Dahl (17) data*
△—*Mixed fission products (17)*

3. Slide back beta shield so that tube is exposed. Rest probe on lid rim with window centered over, and directly facing Standard A. Read meter.

4. Fill container to beaded mark with the water to be tested. Resting the tube detector on container rim (window directly facing the water surface), note the meter reading. If reading is less than that obtained with Standard A, the water may be judged safe for 10-day consumption, during an emergency.

5. If reading is high compared to Standard A, and an emergency condition exists for drinking water, repeat the procedure using Standard B for comparison. If the reading on the water is less than that obtained with Standard B, the water may be used on a 10-day basis. The hazard may be regarded as an acceptable risk for emergency use.

6. As the meter response varies directly with water activity, the water activity may be read from a curve drawn between the points for meter reading against activity for samples A and B.

Training. Method does not require special training in nuclear physics. Laboratory technician can be quickly trained to perform and interpret monitoring results.

Method 2. Landsverk Analysis

Application. For water works laboratory tests during a civilian defense emergency to determine whether drinking water contaminated with radioactivity is within the permissible emergency levels. This method is sensitive below the 10- and 30-day safe and acceptable risk levels.

Fig. 3. Landsverk Model L–75 Analysis Unit

An ionization chamber acts as a radiation detector and a quartz fiber electrometer as an indicator.

Instrument. Landsverk Model L-75 Analysis Unit (Fig. 3). This instrument consists of an ionization chamber as a detector of radiation and a quartz fiber electrometer as the indicator.

Cost of Instrument. Approximately $100 including accessories.

Detection Sensitivity. Sample of 150 ml—10^{-4} to 1 μc per ml (Fig. 4).

Testing Procedure.

1. Fill 3¾-in. diameter plastic dish with 150 ml of sample.

2. Place analysis unit over dish using special adaptor.

3. Charge the electrometer by turning the charging knob slowly in the clockwise direction. If the knob is turned too rapidly, the fiber image may move across the reticle so rapidly that it cannot be observed. The fiber image may then travel beyond the zero point of the reticle and be lost. It takes only about one-fourth turn to fully charge the electrometer after contact is made.

4. When the fiber image has been brought to the vicinity of the zero mark of the reticle, reverse the charger about one-quarter turn to ground it. No charges will then remain on the charger that might affect the reading of the electrometer.

5. With a stopwatch determine the rate of drift of the fiber on the reticle in divisions per minute. This determination gives the background rate of drift. The time interval required for this determination depends on the accuracy that is desired. Roughly, a ten division reading can, with care, be read to ± 2 per cent, and a five division reading to ± 4 per cent.

6. Place the radioactive sample under the ionization chamber and determine the rate of drift of the fiber for the activity plus the background rate of drift. Record divisions per minute.

7. Subtract the background and rate of drift from the total rate to get the net rate of drift from the activity alone.

8. Determine from a calibration chart what the rate of drift in divisions per hour represents in microcuries per milliliter.

9. The instrument should be calibrated against the standard periodically, to be certain that it is functioning properly. A calibrated source of radioactivity may be purchased from the company manufacturing the instrument for $10.

Training. Does not require special training in nuclear physics. Laboratory technicians require only short

training period to perform and interpret results.

Method 3. Proportional Counters

Application. For precise measurement of radioactivity in water ranging from extremely low activity at or just above the natural background to very high activity contaminaton. Will differentiate alpha from beta-gamma radiations. Although this method permits measurement of gross alpha radiation separate from the beta-gamma radiation, identification of the component radioactive source materials requires special radiochemical techniques. Recommended for use in only larger water works and public health department laboratories in critical areas.

Instrument. Proportional counters capable of counting activity from water samples evaporated on planchets (Fig. 5).

Cost of Instrument. From $1,000 to $1,500 with accessories.

Detection Sensitivity. For alpha, 10^{-9} to 1 μc per ml or higher; for beta-gamma, 10^{-8} to 1 μc per ml or higher.

Testing Procedure. Portions of water are evaporated on planchets. The size of sample evaporated depends on the amount of radioactivity present in the water, but certain limitations are imposed on thickness of the deposited salts because of self-absorption by the nonradioactive salts present. For alpha counting 2 to 5 mg of salts may be deposited on each square centimeter of planchet area without introducing an appreciable error due to self-absorption. Thicker deposits may be tolerated for counting beta activity depending on the energy of the radiation. Planchets are placed inside the proportional counter chamber to be counted. Time required for counting may run

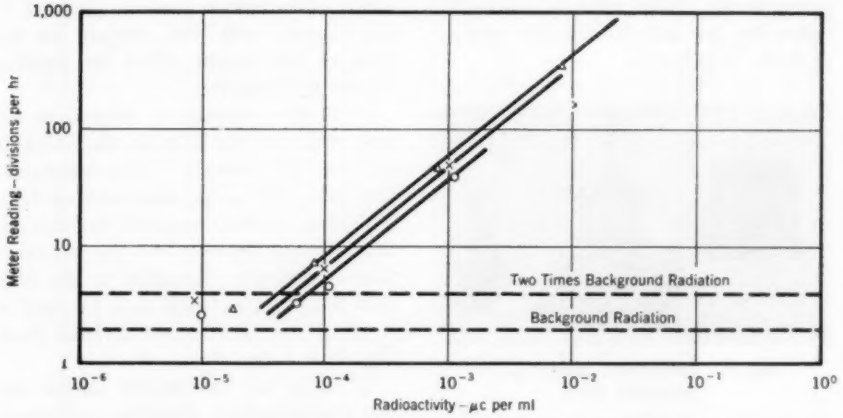

Fig. 4. Calibration of Landsverk Model L–75 Analysis Unit

The water used for calibration was seeded with various amounts of radioactive isotopes which are indicated by the symbols on the figure.

○—*Mixed fission products, 1 yr old*
×—*Strontium*^{90}
△—*Phosphorus*^{32}

from a few minutes to many hours depending on the activity of the sample and the precision of measurement desired.

Training. Requires specialized training in radiation counting techniques and nuclear physics for supervising and interpreting tests. Training of a graduate chemist or engineer in courses similar to those given in the Radioisotope Technic Schools operated by Oak Ridge Institute of Nuclear Studies or the U.S. Public Health Service Environmental Health Center Training Section at Cincinnati, Ohio, should be sufficient to obtain proficiency for supervising the making of these tests. Laboratory technicians may perform work of preparation of samples and counting. Instruments require servicing by skilled electronics technician.

Fig. 5. Proportional Counter

Instrument is used for precise measurement of radioactivity in water ranging from extremely low activity at or just above the natural background to very high activity contamination.

Method 4. Specific Sources

Application. To obtain data on extremely low activities in water arising from naturally occurring radioactive elements. Also for identification of the kind and amount of these elements present in order to determine whether, over a period of time, any increase occurs due to contamination from various radioactive wastes discharged in the watershed of a water supply. Applicable for measurements beyond the range of Method 3. Tests too difficult for most water works laboratories.

Instruments. Extremely sensitive low background proportional counters, or other instruments of suitable type and sensitivity. Capable of counting alpha radiations separate from beta-gamma radiations.

Cost of Instruments. Not known. Special laboratory facilities also required.

Detection Sensitivity. Working range approximately 10^{-10} to 10^{-7} μc per ml.

Testing Procedure. Requires special techniques of evaporation and isolation of individual radioactive isotopes by radiochemical methods. Each radiation must be individually counted. This type of testing should be conducted only in specially equipped shielded laboratories and is not practical for most water works laboratories.

Training. Requires specially trained technicians experienced in nuclear physics and radiochemistry and counting techniques for supervision and interpretation of tests. Technicians working under supervision can carry out sample preparation and counting.

There are many counters on the market which can be used for the various methods, but the Task Group feels the Landsversk Analysis Unit is the best instrument for Method 2 as there is no other instrument available having a comparable usefulness and low price.

References

1. Hecht, Selig. *Explaining the Atom.* Viking Press, New York (1948).
2. Eidinoff, Maxwell L., & Ruchles, H. *Atomics for the Millions.* McGraw-Hill Book Co., New York (1947).
3. Glasstone, Samuel. *Source Book on Atomic Energy.* D. Van Nostrand Co., New York (1950).
4. Atomic Energy Commission & Office of Civilian Defense. The Effects of Atomic Weapons. Supt. of Documents, U.S. Government Printing Office, Washington, D.C. (1950).
5. Radiation and Monitoring Fundamentals for Fire Service. International Assn. of Fire Chiefs. New York (1952).
6. Gray, D. E., & Martens, J. A. *Radiation Monitoring in Atomic Defense.* D. Van Nostrand Co., New York (1951).
7. Lapp, R. E., & Andrews, H. L. *Nuclear Radiation Physics.* Prentice-Hall, New York (1948).
8. Atomic Energy Commission. Glossary of Scientific Terminology Relating to Atomic Energy. Supt. of Documents, U.S. Government Printing Office, Washington, D.C. (1948).
9. Maximum Permissible Amounts of Radioisotopes in the Human Body and Maximum Permissible Concentrations in Air and Water. Report of Subcommittee on Internal Dose, Natl. Com. on Radiation Protection. In Press.
10. What You Should Know About the Atomic Bomb. Surgeon General, Dept. of the Army, Washington, D.C. (1948).
11. Fields, P. R., & Pyle, G. L. Detecting of Trace Amounts of Radioactive Materials. AEC, Office of Technical Services, Dept. of Commerce, Washington, D.C.
12. Pannell, J. H. Radioactivity Measurement Techniques (Revised). AEC, Office of Technical Services, Dept. of Commerce, Washington, D.C. (ACEP-2270).
13. Friedlander, G., & Kennedy, J. W. *Introduction to Radiochemistry.* John Wiley & Sons, New York (1949).
14. Fields, P. R., & Pyle, G. L. Detection of Trace Quantities of Radioactive Materials in Waste Streams. Anal. Chem., **23**:1004 (1951).
15. Cowan, F. P., & Nehemias, J. V. Sensitivity of the Evaporation Method of Liquid-Waste Monitoring. Nucleonics, **7**:39 (Nov. 1950).
16. Schubert, Jack. Estimating Radioelements in Exposed Individuals. Nucleonics, **8**:13 (Feb. 1951); 66 (March 1951); 59 (April 1951).
17. Hursh, J. B.; Zizzo, S.; & Dahl, A. H. Survey Meters for Water Monitoring. Nucleonics, **9**:C–16 (Nov. 1951).
18. Jaffey, A. H.; Kohman, T. P.; & Crawford, J. A. A Manual on the Measurement of Radioactivity. AEC, Office of Technical Services, Dept. of Commerce, Washington, D.C. (MMDC–388).
19. Curtiss, L. F. Measurements of Radioactivity. Natl. Bureau of Standards Circular 476. Supt. of Documents, U.S. Government Printing Office, Washington, D.C. (1949).
20. Blaedel, W. J. Nuclear Chemistry. AEC, Office of Technical Services, Dept of Commerce, Washington, D.C.
21. Morgan, K. Z., et al. Health Physics Insurance Seminar. AEC, Office of Technical Services, Dept. of Commerce, Washington, D.C.
22. AEC Lecture Notes. AEC Health Physics Training Lectures. Office of Technical Services, Washington, D.C.

Discussion

L. R. Setter

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The introductory remarks of the task group report state that there are three major potential sources of radioactive materials that may contaminate water supplies, and that it is important, therefore, that testing facilities for radioactive materials in water be available. The three sources of radioactive materials given are: [1] atomic bombs, [2]

radiological warfare agents, and [3] wastes originating from the manufacture and use of atomic products or isotopes. Recommended instrumentation and testing procedures are given to determine a level of radioactive contamination of water considered to be "tolerable" during civil defense emergencies.

Although the report states that the "tolerable" emergency values are for fission products within the first few days following an atomic explosion, it seems pertinent to emphasize this fact and point out that none of the proposed methods would be suitable for testing contamination resulting from radiological warfare, the manufacture of atomic products, and the peacetime use of radioactive isotopes. There might also be some question of the safety of the emergency level even for recent atomic bomb radioactivity. The "tolerable" level which might be considered an "emergency acceptable risk" assumes that the ingestion of radioactive water will be the only source of harmful radiation. To be realistic, one must assume that many individuals in a civil defense emergency area may have accumulated an external radiation dose approaching an unacceptable risk before drinking the radioactive water. The added effect of drinking water having a safe or emergency level may then produce irreparable damage.

The 10-day emergency beta radiation level of 90 μc per liter assumes fission products of very short half-life. This factor accounts, in part, for the emergency level being roughly one million times higher than the long-time maximum permissible level of 100 $\mu\mu$c per liter (1×10^{-7} μc per ml). Thus, for example, 99 per cent of the gross beta-gamma radioactivity of an exploded bomb may decay or become innocuous in a few days. Similarly, 99.9 per cent of the gross radioactivity may decay in a few weeks. Thereafter, the remaining beta radioactivity decays at a reduced rate and, although all of the ingested radioactivity contributes to the radiation dose, it is customary to single out that fraction of the radioactivity known to have a long biological half-life in estimating the hazard.

The emergency level assumes that the atomic bomb has functioned efficiently, so that there will be relatively little contamination of alpha radiation, but such conditions cannot necessarily be expected. Ingested or inhaled alpha radiation is usually considered to be much more hazardous than beta radiation. Unfortunately, alpha radiation cannot be detected by the first two methods proposed in the task group report.

It is, therefore, the writer's opinion that the emergency standard of water quality adopted by the American Water Works Assn. should be much lower than the so-called 30-day safe level. The writer suggests that 0.1 μc of beta-gamma radioactivity per liter be tentatively considered the 30-day safe value. The emergency standard for alpha contamination should be, roughly, one-twentieth that of the beta standard.

Water supplies suspected of radioactive contamination should, therefore, be assayed for both alpha and beta contamination by sensitive instrumentation and exacting procedures as soon as practical, even though emergency monitoring fails to indicate contamination. Arrangements should be made with key radiological laboratories of institutions, states, and municipalities to provide the necessary tests and consulting service. The collaboration of these laboratories in making spot checks for contamination, in addition to the emergency monitoring of food and water, may be more desirable than

providing emergency water-monitoring devices. Similarly, water supply corporations and large municipalities might well equip key laboratories with trained personnel, adequate equipment, and special supplies for radiological testing to service relatively large areas. The water works profession should train men in radiological techniques and interpretation. Such training is available at the Radiological Health Training Section of the U.S. Public Health Service.

The recommended portable water-monitoring devices for assaying emergency levels of radioactivity have only limited use for other civilian defense purposes which require meters capable of detecting up to 10 r per hr. These instruments usually have ranges of detection 10 to 100 times less sensitive than the beta-gamma probe suggested in Method 1. Nevertheless, they could probably detect an emergency level of radiation if placed above the surface of a large tank or reservoir of water contaminated by a recent atomic bomb explosion. Used in this way, the instrument would serve the dual purpose of area monitoring during civilian defense rescue, fire, and other emergency activity, as well as emergency water monitoring.

Opinions differ on the training of personnel for the use and maintenance of instruments and the interpretation of radioactivity measurements. Some instruments, such as the quartz fiber electrometers, are so delicate that unless they are handled carefully, they will become inoperative and must be returned to the factory for repair. The directions for use of portable Geiger-Muller survey meters and electrometers are simple and require a minimum of training. Considerably more training is necessary, however, to understand the limitations of these instruments and the significance of readings.

Proportional counters capable of assaying alpha and beta radiation near background levels or higher will require similar, but perhaps more extensive, training than that required for the Geiger-Muller counters. The technique of measurement is no more intricate, however, than the use of a pH electrometer or photoelectrometer, but the electronic circuits are more complicated and may occasionally require the maintenance services of a good radio technician. The greatest need of training is in the fundamentals of radiation, units of measurement, and laboratory procedure which, though special, are comparable to general water analyses. Such training, geared to sanitary chemists and engineers, could be provided by institutions of learning as short courses of one to two weeks duration, and are being given at the U.S. Public Health Service Environmental Health Center, Cincinnati, Ohio.

Fluoridation Experiences From a Manager's Viewpoint

Panel Discussion

A panel discussion presented on May 7, 1952, at the Annual Conference, Kansas City, Mo.

W. Victor Weir

President & General Mgr., St. Louis County Water Co., St. Louis, Mo.

THE subject of fluoridation of public water supplies has been discussed at many AWWA meetings, principally by dental and public health experts. As men with these qualifications are not included in this panel, the dental and public health aspects of the fluoridation problem will not be included in this discussion. The discussers are water works men in management positions, and, from their first-hand experiences they present fluoridation problems and solutions from management's viewpoint.

Most water works men have had some experience in considering the addition of fluorides to water supplies, but few have dealt with all the problems leading to a decision to begin fluoridation, or with the problems arising after fluoridation has been started. Only a few hundred of the many thousand public water supplies are being fluoridated. Therefore, the experiences of those who have dealt with the various aspects of the fluoridation problem are valuable to most water works superintendents and managers.

Fluoridation problems arise because the water works utility distributes water—not H_2O. No water works produces "pure" water—that is, pure in the chemical sense—and no one expects it to. If the product contained only hydrogen and oxygen, anything else added would obviously be an adulterant. The water works profession might then be in a position to object to adding anything, including fluorides; and fluoridation would not be a management headache today. Chemically pure water, however, would cause so many distribution system and plumbing troubles that the water works and its customers would soon insist upon the addition of various chemicals to the water supplies.

Water works people have had a fairly free hand in deciding what to add or subtract from the water supply. Standards have been established for the amounts of various chemical elements and compounds which can be present in water supplies. These standards, generally maximums, have been somewhat flexible and have been changed from time to time as it has been found necessary and desirable. Disinfecting agents—chlorine, chlorine compounds, ammonia, ammonia compounds, or ozone—are all added in various combinations. The allowable amount of copper has been increased in recent years, and some water sup-

plies consequently carry higher residuals. Aluminum and iron salts, some of which may remain in the finished water, although they were never in the original supply, are added. Some water works remove calcium, whereas others add it to make the water harder and less corrosive. Some add silicates and metaphosphates to prevent pipe and plumbing "caries" or the "mottling" of clothes by iron precipitates. The sodium content of water may be increased several times by using ion-exchange treatment, although little is known of the medical significance.

These chemicals have been added to produce what is believed to be a more acceptable water quality. The author feels they have all been added because water works managements chose to add them. There was no public clamor for any of them, although there would be if the treatment of water supplies was discontinued. There have been objections to certain practices, but the objections are now largely forgotten.

On two occasions the public, rather than water works people, wanted chemicals added to the water supply. Approximately 30 years ago, it was requested that iodine be added to prevent goiter in certain iodine-deficient areas. Only one water supply began the addition of sodium iodide before it was found more efficacious to add the substance to table salt.

The present demand is for the addition of fluorides to water supplies alleged to be deficient in this element, for the partial control of dental caries. Although fluoridation began as controlled experiments in a few selected cities, the procedure has "snowballed" far beyond the controlled experiment group. The water works manager or superintendent who has not had to consider fluoridation actively will soon be the exception.

This panel is limited to the discussion of fluoridation problems which directly affect water works management, and with which water works management should be concerned. Whether fluoridation is desirable or undesirable will not be discussed, as this is a dental, medical, and public health problem. Whether the water supply is the best vehicle for carrying fluorides to the citizens is also a dental, medical, and public health problem. Nor will this panel discuss the technical problems of materials, equipment, and controls.

The problems discussed are those of current primary interest to management:

1. What may be expected from citizen pressure, organized or unorganized, sponsoring or opposed to fluoridation?
2. What position should the water works manager or superintendent take during the period of promotion of fluoridation?
3. Should management insist that it receive protective clearance from the dental, medical, public health, and governmental authorities before fluoridation is started?
4. How should the cost of fluoridation be met?
5. What responsibilities fall upon the water utility and its management when it adds fluorides to the water supply? Are legal liabilities involved, and how serious may they be? How may they be minimized?
6. Will fluoridation bring new personnel problems?
7. How should water works public relations be handled before and after fluorides are added?

Walter M. Franklin

General Supt., Water Dept. & Sewage Treatment Works, Charlotte, N.C.

A water utility, whether privately or publicly owned, is inevitably held morally and legally responsible for the potability of the water furnished its customers. The importance of a potable water supply to any community, taken together with the fact that there is normally no competition in this field, eliminates any sound grounds for attempting to evade these responsibilities. It would seem, however, that when a fluoridation program is contemplated, utilizing the community water supply as a medium for its application, the basic responsibility for the program rests with the dental and medical agencies either at the local or state level, or both. It follows, therefore, that the water utility should act only as a coordinating agency.

The application of fluoride to a water supply does not affect the potability of that supply in the sense usually employed by the water works industry. Water works have been informed that the addition of too small an amount of fluoride does no good, and that the addition of too much may prove harmful, and, therefore, a carefully controlled dosage must be applied in order to accomplish the desired results. The water works industry has no method of evaluating the final results of fluoridation in its own laboratories in the manner it handles the normal purification and treatment processes. Fluoridation must be considered a long-range program of preventive dentistry and it should be handled as such by water works management from the very outset. The course then left open to the water utility is that of confining its activities entirely to the execution of the program as directed officially by a responsible health agency. Thus, it is quite evident that certain responsibilities may conscientiously be passed on to the health agency and the water utility, of necessity, may take certain protective steps to see that this responsibility officially rests with the proper authorities. The policy necessary for establishing these responsibilities has already been outlined by the AWWA in its recommended procedure for fluoridation (1).

In planning a fluoridation program, one must not lose sight of the basic principle that a water utility can legally be held responsible for the purity of the water which it furnishes its customers. The fact that negligence must be proved before damages may be collected does not change the fact that undue criticism and bad publicity do not add to the confidence the general public has in its water utility. A water utility which enjoys the full confidence of its customers is indeed in an enviable position. In order to preserve this reputation, the responsibilities of a fluoridation program should be fully explained to the public, and established upon facts.

Charlotte, N.C., Experience

The procedure used in Charlotte, N.C., in establishing a fluoridation program will more clearly demonstrate the placement of responsibility and the method of informing the public. Fluoridation was first advocated by officials of the Charlotte Health Dept., particularly the dental section, under the direction of Zachary Stadt in January 1947, and the matter was followed through by all the facilities of the department under the direction of B. M. Bethel.

The city health authorities first secured the approval of the Charlotte Dental Society and the Mecklenburg County Medical Society during the early months of 1947. Their first approach to the officials of the water department was made in March 1947. During this conference these societies solicited the technical aid of the water department staff in developing the mechanical and chemical features of the program. The water department was able to answer their questions about the actual application of the fluorine compounds.

The management of the water department maintained a strictly neutral attitude about the benefits to be derived from a fluoridation program, but insisted that the program be financed by the health agencies and operated under their definite instructions and responsibility. The water department assured the health agencies it would act only as a coordinating agency and would take such steps as it deemed necessary to protect the department from undue liability and criticism. The health department officials were agreeable, so that a period of cooperation was enjoyed from the outset.

With this understanding the water and health department officials consulted the city manager and received his approval. The health department then proceeded with an educational program designed for the general public and carried out with the aid and approval of various civic organizations, including the Parent-Teachers Assn. and the Junior Chamber of Commerce. The approval of the North Carolina State Board of Health and the district officials of the U.S. Public Health Service was obtained. The mayor aided the program in various ways, particularly by recommending to the city council that fluoridation be approved for Charlotte.

Throughout the month of June 1948, committees from various civic and professional organizations appeared at successive council meetings and the matter was thoroughly discussed in open meetings. The newspapers widely publicized the facts as presented to the city council. Very little opposition was registered in disapproval of the program. The campaign was concluded when the city council authorized, by resolution, the fluoridation of the water supply on June 24, 1948, and established funds in the health department budget for carrying out the program. The program was to be initiated as quickly as material and equipment could be procured and placed in operation.

The adoption of fluoridation practices brought to a successful conclusion an educational program which the health department had conducted over a period of one and one-half years. The whole procedure was handled in a democratic manner. The action of any governing body, such as the city council, is to be construed as a mandate of the majority of the people whom they serve. Under the procedure used in Charlotte, it would seem absolutely out of order and unnecessary to call for a referendum on the fluoridation program. A referendum was never seriously considered.

The water department was immediately notified, officially, to proceed with its part of the cooperative program. To this end, the city attorney was consulted and also the attorney general of the state of North Carolina regarding legal difficulties, present and future, which might affect the water

TABLE 1

*Application of Sodium Silicofluoride to Water Supply**

Day of Week	Filtered Water Treated *mil gal*	Water Pumped Plus Wash Water *mil gal*	Sodium Silicofluoride Dosage					Fluoride Determinations *ppm*		
			To Feeder *lb*	To Water *lb*	Rate *lb per mil gal*	Concentration *ppm*†		Filtration Plant	Tap Water	Distribution System
						As Na_2SiF_6	As F			
Sunday	8.785	10.888	—	143	16.3	1.95	1.17	0.05	1.10	—
Monday	16.020	15.142	250	254	15.9	1.91	1.14	0.05	1.10	1.20
Tuesday	14.550	14.907	250	232	15.9	1.91	1.15	0.05	1.10	1.10
Wednesday	14.600	15.105	250	231	15.8	1.90	1.14	0.05	1.15	1.15
Thursday	14.915	14.858	250	240	16.0	1.92	1.15	0.05	1.15	1.10
Friday	14.900	15.276	250	239	16.0	1.92	1.15	0.05	1.15	1.20
Saturday	14.895	13.486	250	239	16.0	1.92	1.15	0.05	1.15	1.15
Total	98.665	99.662	1500	1578	16.0 (avg)	1.92 (avg)	1.15 (avg)	0.05 (avg)	1.13 (avg)	1.15 (avg)

*For week ending Feb. 9, 1952.
† Calculated from estimated filtered water treated.

Inventory of Sodium Silicofluoride, lb.

On hand beginning of week	18,280
Received during week	0
Total available	18,280
Used during week	1,578
Actual physical inventory	16,685
Inventory loss	17
Actual use during week	1,595

Signed:

.....

Plant Superintendent

APPROVED:

.....

Superintendent Water Dept.

utility's responsibilities. The only difficulty uncovered by the counsel was the fact that the water department could be held liable for alleged or actual damages due to the presence of fluorine compounds in the water supply, if negligence could be proved. That the water department was acting only as a coordinating agency was looked upon with favor by the counsel. Before proceeding with the program, the author, representing the water department, and the dental officer, representing the health department, made an inspection trip to Evanston, Ill., and Grand Rapids, Mich., to check first hand on the various aspects of the fluoridation program as set up in these two cities. Horace R. Frye of the Evanston Water Dept. and William L. Harris of the Grand Rapids Water Dept. were cordial and cooperative and rendered every possible assistance. The information secured enabled the water department

to advise the health department further on the type of equipment and chemicals that would be required.

Plan of Operation

Further conferences with the health department officials resulted in a plan of operation. The health department requested that the water department recommend the type of equipment and materials to be used and to procure and install them at health department expense. The fluorine compounds were to be added to the water supply according to a schedule supplied by the health department officials who would also have their personnel check the results throughout the distribution system. The water department staff was to check the results in the plant and throughout the distribution system and maintain accurate records of the operation and results. A report form (Table 1) was designed by the water department staff covering all phases of the program. The report form shows the amount of water treated daily, the amount of fluorine compounds added, the residual fluorine content obtained both at the plant and in various parts of the distribution system, and a running inventory of the amount of fluorine compounds used, unaccounted for, and on hand. It was to be filed weekly with the Charlotte Health Dept. and with the North Carolina State Board of Health. This type of report has proved invaluable in protecting the water department against unfounded rumors and the recorded data have placed the program on a sound basis. The author feels this type of record is absolutely necessary in a coordinating program such as that used in Charlotte. A loss-in-weight type dry feeder with recording gages was recommended and obtained, and further aids the water department in keeping authentic records.

The application of fluorine was officially begun on April 1, 1949. Appropriate ceremonies were conducted by the Mayor and city council, and representatives of various civic organizations were present. The local radio station broadcast the program. The water department requested that the actual application of fluorine be secretly delayed for a few weeks in order to secure the reaction of the public. The actual application of fluorine compounds was begun on April 25, 1949. The program has been conducted without undue criticism since that time. There has been one minor interruption resulting from difficulty in the manufacturing of ice, but this problem was quickly solved (2).

It was most gratifying to the author that the procedure adopted by the city of Charlotte in handling this program was essentially that later adopted by the American Water Works Assn. as a standard procedure.

Conclusion

The protective measures taken by the Charlotte Water Dept. included:

1. Assurance that the program was approved by the people of Charlotte. The program was widely and thoroughly publicized and was backed by a resolution adopted by the city council.
2. Assurance that the program was approved by both local and state health authorities.
3. Establishment of the responsibility of the health agencies for the rate of application and financing, and establishment of the fact that the water department was only a coordinating agency.

4. Securing full information from legal counsel on the ultimate responsibility to be shared by the water department.

5. Establishment of a system of procedure and records covering the program.

6. Providing adequate safety measures for the use of fluorine compounds by both water purification plant employees and the general public.

7. Filing the proper records with the responsible agencies.

References

1. The Fluoridation of Public Water Supplies—AWWA B700-49. Am. Water Works Assn., New York (1949); *see also* Jour. AWWA, **41**:575 (July 1949).
2. STADT, ZACHARY M., & PHILLIPS, ROBERT S. Effect of Fluoridated Water in Ice Manufacturing. Jour. AWWA, **41**: 1069 (Dec. 1949).

James E. Kerslake

Superintendent of Filtration, Water Purification Plant, Milwaukee, Wis.

The city of Milwaukee has installed equipment for the application of sodium silicofluoride (Na_2SiF_6) to the municipal water supply. The application has been delayed until permission has been received from the Utilities Committee of the Common Council. The city health commissioner has also been consulted. The industries served have requested that application be delayed until they have completed their investigations into the effect the addition of a fluorine compound to the municipal water supply will have on their products. Industrial consumption in Milwaukee is almost 40 per cent of the total.

Installation

The installation consists of two gravimetric scale dry feeders. Each machine has a capacity of 6,000 lb per day or 250 lb per hr. The dose is 14 lb per mil gal and each machine is capable of treating water at the rate of 400 mgd. Sodium silicofluoride is discharged from the belt directly into a stainless steel vortex bowl where it is carried in suspension to the point of application. The suspension is conveyed in rubber, plastic, and stainless steel. Using this type of construction it is not necessary to provide a solution tank. The suspension goes into solution rapidly at the point of application. A storage bunker having a capacity of 40,000 lb was built inside one of the spare storage bunkers. It has straight sides and will not require that a man go into the bunker to loosen the material being fed. Each machine is provided with a 2,000-lb conical feed hopper and a suction fan. The discharge from the suction fan is through a bag filter.

All equipment was installed by plant personnel. Wiring and calibration of the dry feed machines were included in the price of the equipment. The total cost for the material was approximately $11,000, including the bag dump, two dry-feed machines, valves, pipe and fittings, and safety equipment. Details of the costs are given in Table 1.

Safety Precautions

The operators are trained in handling fluorides at the plant. Cooperation is received from the staff of the state health department. The most important requirement, from the viewpoint of safety, is to provide all possible protection when the equipment is designed and installed. Experience in Milwau-

TABLE 1

*Cost of Sodium Silicofluoride Application to Milwaukee Water Supply**

Storage Bunker (Capacity approx. 40,000 lb)		
Steel plate, angle iron, hardware		$ 486.10
Bag Dump		
Bag dump	$ 504.00	
Vent pipe	13.83	
12-in. feed pipe (dump to storage bunker)	291.80	809.63
Dry Feed Machines†		
Two machines at $3,198 each	6,396.00	
Ejectors	13.72	
Hangers	21.00	
Paint	18.75	6,449.47
Valves, Piping, and Fittings		
Meters, stainless steel, rubber hose, and plastic pipe		2,435.65
Safety Equipment		
Masks, rubber gloves, rubber aprons, 12 sets		289.79
Miscellaneous		
Skids (30)	373.80	
Motors	47.08	420.88
		$10,891.52

* Equipment was installed by plant personnel. The manufacturer wired and calibrated the feeders.
† Includes a feed hopper with 2,000-lb capacity for each machine.

kee has, so far, been limited, but the biggest problem appears to be getting the men to wear the safety equipment that has been provided. The men do not like to wear the rubber gloves. Rubber is used so that the gloves can be readily washed. The type purchased has corrugated fingers and palms so that bags can be handled without slipping, but after a short time, the men's hands perspire to an uncomfortable extent.

Sodium silicofluoride is shipped in 100-lb multiwall paper bags and is received in truck-load lots of 10 tons each. Rotating the men who unload the trucks and dump the material into the storage bunker is expected to bring the incidence of exposure so low that there will be no possible danger to them. The Milwaukee Water Dept. expects to handle from 5 to 6 tons per week. As soon as sodium silicofluoride application is started and a schedule is worked out, a member of the staff of the state health department will take air samples and help keep the hazard from dust to a minimum.

The sodium silicofluoride may be added to the raw water or to the plant effluent. Before the equipment was designed, plant runs were made using one of the spare ammonium sulfate feeders. With an 80 lb per mil gal dose of alum there was no loss of fluoride when sodium silicofluoride was applied to the raw water ahead of the mixing chamber. In laboratory experiments, there was a 10 per cent loss when the alum dose was increased to 120 and 140 lb per mil gal. The average alum dose is between 80 and 90 lb per mil gal and very seldom exceeds 120 lb.

Effect on Pay Rates

The Milwaukee Water Dept. is completely unionized. Management expects that the men will emphasize the added responsibility of the application of fluorides when asking for higher pay rates at budget time. Pay rates are a matter of classification. As long as the city pays prevailing rates to the building trades and guarantees them 2,000 hr per year with sick leave and pen-

sions, the water department will be faced with demands for like pay from its personnel. Many industries are paying differential rates for shift workers and time and one-half for Saturdays and double time for Sundays. The water department is now paying overtime for more than 8 hr per day and 40 hr per week, and for holiday work. Thus, anyone who works 40 hr in a week in which a holiday occurs, receives 12 hr overtime. The matter of pay is a complicated one and now that the unions are taking over, water departments will be faced with the problem of studying pay rates in detail and will probably have to change previous ideas whether they like it or not.

John E. Kleinhenz

Publicity Director, Indianapolis Water Co., Indianapolis, Ind.

Although the Indianapolis Water Co. just started a fluoridation program in August 1951, a glance at the clippings on fluoridation might indicate that the company has been urging it for years. The first reference to fluoridation appeared in 1940 and 1942 and then every year after 1945. The clippings were not of general import but dealt with fluoridation in Indianapolis and Indiana. The Indianapolis editors and reporters, many of whom are Indiana University graduates, were probably especially interested in fluoridation because the Indiana University School of Dentistry pioneered in the use of fluorine.

Pressure for Fluoridation

In August 1945, the author received a note from a friend in an advertising agency who, after reading a doctor's syndicated column, asked: "Are my kids going to be snaggletoothed because the Indianapolis Water Co. won't put fluorine in the water? Or are you already doing it?" The author told him that the company was keeping in touch with the developments in fluoridation and with the experiments just then starting in several towns around the country. It gave the author pleasure to inform him in 1951 that the company was now fluoridating as he had requested six years before. He replied, however, that his son was now too old to benefit from the program.

In May 1946, three supervisors from a local industry wrote the manager, enclosing a clipping from the Dow Chemical Co. house organ, *The Diamond* advocating fluoridation. They said in part: "We would be more than glad to pay the additional cost involved if it is as beneficial as is claimed." They also thought a poll of customers would find a majority in favor even if it resulted in an increase in the cost of their service. They added that the public should be properly informed—an all-important matter. The company told them of the experimental work then being conducted.

In 1947, after an article appeared in a national weekly magazine, the company received a letter which stated: "Your only probable reward would be the greater good will of your patrons, but for myself, with a four-year-old son, I would gladly pay more for water service to avoid suffering among our children and others." The company answered: "until the proper authorities approve such treatment or the addition of fluorides, it seems that such treatment should be prescribed for each individual by a physician. Some persons may be affected adversely."

In 1946 or 1947, the Indiana University School of Dentistry began experimental topical applications of sodium fluoride to the teeth of children in one local school. Their experiences may have paved the way for the inauguration of the program of fluoridation of the community's public water supply.

Endorsement

In January 1951 things began to move. The Indiana Dental Assn. endorsed fluoridation at its convention, and sent its official endorsement to the city board of health on Jan. 27. The city medical association did likewise on Feb. 7, and on March 23, the City Board of Health and Hospitals asked the Indianapolis Water Co. to submit plans for fluoridation to the State Board of Health and to start the program as soon as possible. The cost of fluoridation was included in the company's petition for increased rates that was filed with the Public Service Commission of Indiana on Dec. 28, 1950, and when the increase was granted, the second major item mentioned in the newspaper stories was the authorization of fluoridation.

Informing the Public

At no time did the company try, or feel that it was entitled to take any credit for the fluoridation program. Rather, it gave the program its dignified acquiescence and whole-hearted cooperation.

Finally the plans were completed and the program was to be started on August 8. Reporters were always kept informed of developments. The company considered announcing a false date for the start of the fluoridation, just to have the edge on those whose imagination would cause them to notice a taste or odor in the water. But it was decided that this practice would not be fair play—nor would the contrary—the starting of fluoridation a week or so before announcing it. In addition, such practices might affect some people who were taking fluorine on doctor's orders.

The company prepared news stories containing all the necessary information for the daily papers. The April 1951 release of "Willing Water" (1) including his questions and answers on the fluoridation issue was attached to the news stories. The stories were accurate, and the headlines and artwork added by the newspapers were favorable. One of the editorials, entitled "One in a Million" (2), stated:

> Something new will be added to what Indianapolis drinks after August 8—a small amount of fluorine salt, sufficient to bring the fluorine content of the city's water up to one part per million.
>
> Small things can be important, however. The one-millionth part of fluorine will be impossible to detect by taste or odor; to all appearances the water will be just the same as before. But there will be a significant difference from the standpoint of the city's health. The generation of children who have not yet acquired their permanent teeth will have as much as 60 per cent fewer dental cavities. They will have fewer painful sessions with the dentist, and their teeth will be stronger and more lasting.
>
> This contribution to a better and more toothsome community by the Indianapolis Water Co. has the stamp of approval of the American Dental Assn., the Indianapolis Dental and Medical Societies, the Board of Health, and the American Water Works Assn. It will be approved also, no doubt, by everyone who has ever had to herd a child into a dentist's office and even by those plated and dentured adults

who sigh for the days when corn on the cob was a treat rather than a treatment. They, it seems, were born 30 years too soon.

The Indianapolis Water Co.'s newspaper advertisement required much thought. People were invited to write, call, or stop in the company offices for a folder on fluoridation, but only approximately ten did. The advertisement stated briefly the purpose of the program and listed the approving agencies, but did not attempt to claim credit for the Indianapolis Water Co. One advertisement was run a week ahead of the date of starting, the others the day before or the morning of the inauguration. Advance copies were sent to the mayor, the public service commission members, the medical and dental societies, the city and state boards of health, and a few others. Favorable letters were received in response, and the company felt that it had acted properly.

One adverse letter—from a lady who lived outside the company service area—was received the day before the start. It contained some quotes from a pamphlet entitled, "Americanism Bulletin," which contained a lot of misleading statements on fluoridation. The letter was answered informatively and no reaction was received, so apparently she was "sold" on fluoridation.

The radio carried the general news of the program to the people, but the television station in Indianapolis emphasized it. There were two separate programs featuring a panel on the subject. The first was on Aug. 6, two days before the start, and featured the company's purification superintendent, Marshall Crabill, Gerald Kempf of the city Board of Health, and Maynard Hine of the Indiana University School of Dentistry. This program was that of a popular newscaster and had many viewers. On the night of Aug. 8, the starting date, another panel discussion took place featuring George Fassnacht of the Indiana State Board of Health, Charles Howell of the dental section of the Indiana State Board of Health, A. O. Norris, Mgr., Indianapolis Water Co., and Marshall Crabill.

The people seemed somewhat apathetic. Perhaps that could be taken as a compliment to the company—that they felt the company wouldn't do anything to harm them—or perhaps they were already aware of the benefits and the technical angles.

Religious Opposition

There was some opposition by religious groups to the fluoridation program, but it was not publicized. Several members of the author's family belong to the principal church which opposed the program, and, naturally, the author was asked many questions about fluoridation. The author explained that the proper officer of the church had filed the necessary objection with the State Board of Health and that local or individual action was not necessary or desirable. The principle of fluoridation was also explained and the relatives were convinced that it was not mass medication—that many localities had fluorides in their water of the right proportions and that the company already had a little in each of its sources of supply. Thus, the company was merely increasing the natural content to 1 ppm. The author also stressed that these people went to the dentist to have their teeth repaired, and emphasized that fluoridation would keep their children and

grandchildren from going to the dentist, perhaps ever.

Inquiries

Inquiries were received about the effect of fluoridation on goldfish—both from individuals and from a local store. Both the individuals and the stores received a detailed and technical answer, but the author found that the best answer was to tell them about the aquarium filled with healthy goldfish in the company's office lobby.

Another inquiry concerned mice. A local industry supplied mice to one of the state universities for fluoridation experimentation, and the operators missed the news that fluoridation had been started in August. Of course the mice at the university laboratory began to show some peculiar results from the prefluoridation they had received through our supply. Apparently the industry changed its water supply, for nothing more has been heard from them.

Before the program was started, the company advised the local ice industry association of the problem of ice cracking which was noted in the literature. A recent recheck with the association indicated that no trouble has been experienced.

A short time ago a local food packing company mentioned a remark made by a speaker on a food processing program in another state. The remark was interpreted as meaning that the Food and Drug Administration was considering the establishment of an upper limit for fluorides. A check with the health authorities in Indianapolis revealed that they had no knowledge of such a proposal. The company feels that the U.S. Public Health Service standards for drinking water would guide the food and drug people if such a development occurred.

Early in the program a fruit juice company which diluted their product with Indianapolis water called the company for information. The food and drug laws were checked and the fruit juice company was assured that the fluoridated water would be satisfactory. Nothing more has been heard, so apparently all went well.

Recently a local pharmaceutical plant, the largest individual user of water in the city, experienced trouble with the pH of their distilled water. They were most cooperative and did their own processing.

There were several minor telephone calls. A few were from people already receiving fluorides; they were advised to check with their doctors for reduction in their prescription, if necessary. There were a few casual inquiries about taste, odor, or use of the water on the lawn. All answers satisfied the inquirers.

One call from a newspaper, just a few days after the start of the program, concerned a woman who had informed the reporter that her four children had been made sick by fluorine. The company checked with the State Board of Health and found that they would investigate if the woman's doctor would make a report or complaint. The reporter gave this information to the woman but nothing came of it—probably a case of green apples.

There has been no complaint of record from any dentist, and only one from a doctor who apparently had been reading the "opposition" literature. He was a member of the local medical society, but had registered no protest when the group adopted a resolution in favor of fluoridation.

The author recently checked with the executive secretaries of both the medical and dental associations and the newspapers, and found that no adverse comments had been received.

The Indianapolis Water Co. has received inquiries from other cities about the program. These inquiries mainly concerned costs and equipment and came from water companies, civic groups, especially the Junior Chamber of Commerce, and individuals.

The public was informed about fluoridation by methods other than advertisements and newspaper stories. The employees were good public relations people. In the employee publication of Apr. 13, 1951, after the formal request by the City Board of Health, a general news story was written. In the next issue, Apr. 27, a reprint of the fluoridation issue of *Willing Water* (1) was enclosed. On May 25, the rate decision of the public service commission was announced and the authorization of fluoridation was reported. On Aug. 3, just before the start of the program, a complete story, with pictures of equipment and operation, was used. It is assumed that each employee favorably influenced several other persons. The author feels the employees were also impressed with the company's concern for their safety in handling sodium fluoride in the concentrated form, as the company requires those handling the chemical to take physical examinations and follow safety precautions.

Student nurses from a state university now take tours through the purification plant to see the fluoridation program in action, as a part of their training course. Each year for the past three there have been visitations from teachers for a Business-Industry-Education Day. They tour the plant, have lunch, listen to a discussion of water works operations, and ask questions, many of which are about fluoridation.

When the company movie is shown at schools, both teachers and students have shown much interest in, have been well informed on, and are favorable to fluoridation. At many showings before the general public—civic clubs and luncheon clubs—however, the anticipated questions were not asked, so the author asked, "Do you know about the new chemical being added?" Two humorous reactions included: "Well, I won't worry about the enamel on the bathtub any more," and "Will it help my teeth if I let them soak overnight?"

Another time the author was taking movies of fountains for future use in a film. One fountain was covered with green scum—it hadn't been cleaned recently. An elderly man on the sidewalk asked if the fluorine had caused the scum; he and his wife had stopped drinking water as they didn't want their stomachs turned green. The author explained, quite seriously, but still doesn't know if he was being kidded.

Mass reaction could be expected at the Home Show, a local exposition attended annually by a hundred thousand people. In 1951 the show took place in the midst of the rate increase request, but there were very few queries about the increase and only one about fluoridation. In 1952 there were only three or four queries at the show. The company had a water bar at the show ("Your Best Drink Bar None") and expected some gags about "chlorine cocktail" or "fluorine cocktail" but there were few indeed.

At the State Fair last year, the dental section of the State Board of Health did some promotion work. A sign was placed by the drinking fountain stating, "You are drinking fluoridated water." One man from the board watched a fountain and said that one person, after getting a very satisfying drink, observed the sign, and immediately changed his expression. The watcher hastened to assure him that the water was safe.

Conclusion

The first requisite to inform the public about fluoridation is to give them a better understanding of it, and to do so the water works man must have that understanding himself. Information must be given freely to the newspapermen. They are, for the most part, willing to help. Whole-hearted cooperation should be given to the State Board of Health. Usually they know a lot more about fluoridation than the water works man. The water works man should be willing to sit down with city officials—the mayor, health officers, and medical and dental groups—to discuss the entire matter. A panel discussion with qualified members would be the ideal method. Finally, the best public relations people for a company are its employees. Tell them —sell them—and you'll make a city of friends for your company and its operations.

References

1. Questions and Answers on Fluoridation of Public Water Supplies. *Willing Water* No. 14. Am. Water Works Assn., New York (Apr. 1951).
2. One in a Million. Editorial in the Indianapolis *News*, Aug. 3, 1951.

G. Guy Morrow

Mgr., Peoria Water Works Co., Peoria, Ill.

Fluoridation has been promoted in Peoria both actively and inactively. Although the active period of promotion has ended, all promotion has not, and is, at the present time, only dormant.

Committee Meetings

The chairman of a committee of the dental association, appointed to study and promote fluoridation, first requested a meeting with the writer in early April 1951. At this meeting the dentists offered excellent arguments in support of fluoridation. There was no doubt that they had obtained practically all of the available information on the subject at that time. During that meeting and in subsequent meetings, the water works policy was to listen and not to oppose fluoridation. As a consequence, there was always a mutual feeling of cordiality. No publicity was given any of the meetings with the water works company.

At the second meeting with the fluoridation committee of the dental association on May 4, 1951, the water works company presented some tentative cost figures. The question of approval by the various health departments, medical society, and municipal authorities was also discussed, and the questions of who would pay the cost of the treatment, and on whom the responsibility for any damages would rest, were given consideration.

The fluoridation committee continued its promotional work through the summer of 1951, and in September went to the City Council with a resolution which, if adopted, would put the

council on record favoring fluoridation. The councilmen discussed the resolution but did not adopt it. A prominent newspaperman spoke in opposition to fluoridation at this council meeting. After this meeting, the proposal began to receive active publicity.

The council asked its health committee to study the question and make a recommendation to the council on it. The chairman of the health committee requested that the public write him expressing their views on the matter, and he also announced that a public meeting would be held early in October 1951 to discuss the question.

Public Meeting

The public meeting was held as scheduled, but the attendance was disappointingly small. The chairman announced that he had received 200 letters, and that the views expressed were about equally divided on the subject. A prominent member of the Christian Science Church spoke in opposition to fluoridation. The chairman of the dental health committee read a paper favoring it, and various councilmen asked questions and had somewhat heated arguments about it. At the end of that meeting the chairman announced that he would report to the council with a recommendation at the next regular meeting.

The health committee reported that evidence offered by the promoters was not sufficient to warrant action by the council and recommended that the resolution be returned to the dental association with the statement that the council was not going to be hasty in approving fluoridation, and would not consider it at all unless the medical society sent in a written approval. The medical society had not approved the resolution at any time. The Council voted to return the resolution to the dental association.

Continued Study

There has been no public agitation for fluoridation since October 1951. A few articles on both sides of the issue have appeared in the newspapers, but since early 1952 there has been little notice of the matter. The Health and Sanitation Committee of the Association of Commerce has continued its study of the question, however, and recently sent a report on its findings to the association's board of directors. This report mentioned that there was merit in fluoridation, but, as there were a number of points on which objections had been raised, the committee felt that it would be unwise to try to obtain public approval at this time. The objectionable points included: [1] no experiments had been completed; [2] many believed fluoridation bordered on socialism; and [3] there is insufficient evidence about its toxic effect. The committee, of which the author is a member, stated that it would continue to study all aspects of the program, seek more definite knowledge, and watch future developments.

Water Works Policy

The policy of the Peoria Water Works Co. has been to view fluoridation objectively and not to oppose it. The company has always been interested in any factual material offered by both promoters and opponents. A cordial feeling between those promoting fluoridation and the water company has been maintained at all times.

The author feels that, in general, the proponents of fluoridation in Peoria have been, and are, approaching the

problem in a sensible manner. It would not be desirable, nor would a successful conclusion be reached, were they to advance publicly some of the wild and unfounded claims made occasionally by some promoters of fluoridation.

It will be necessary, in Peoria, to have a referendum on the matter, and if those favoring fluoridation were to depart from an objective approach to the matter, it could become very controversial, and the author firmly believes the voters would disapprove. If it were turned down by the voters in a referendum as it has been elsewhere, it could be a long time before it could be successfully revived. It is the author's conclusion, therefore, that those favoring fluoridation should go slowly in promoting it.

John H. Murdoch Jr.

Vice President & Counsel, American Water Works Service Co., Philadelphia, Pa.

As there is neither statutory nor case law which directly concerns fluoridation of public water supplies, any discussion of the legal problems facing water works managers and operators must, of necessity, consist of a lawyer's personal opinions. Some statutes in existence are troublesome, but the author will only indicate the nature of these statutes without citations.

In some states the statutes dealing with the powers, duties, and public or corporate functions of municipalities and public water supply companies leave some lawyers in doubt whether the municipal water departments or water companies of those states have the corporate power to undertake fluoridation. In Pennsylvania, for example, water companies are given power to supply water to the public but the law says nothing about the company having the right to make that water a means of carrying other constituents to consumers. Although the chances of serious trouble for water purveyors under these statutes are slight if the general public is determined to have a fluoridated public water supply, the necessary legislation should be adopted, as soon as possible, to clarify the situation.

Food and Drug Laws

Various pure food and drug acts should also be amended to remove uncertainty. In some states these acts prohibit the sale or delivery of foods or drinks containing poisons. If the statutes refer to foods only, some take the position that water is a food, and that the statutes cover the addition of fluorides to water. Many states forbid the sale of nonalcoholic beverages containing, among other things, fluorides. Trouble for a water purveyor might easily develop if the fluoridated water were used by a bottler and the bottler faced prosecution or loss of business under such a pure food act.

The situation would not fall within the evils which the pure food act seeks to cure and courts might refuse to apply those acts when properly controlled fluoridation was alone involved but, here again, the proponents of fluoridation should be urged to have new legislation adopted.

All water works managers should definitely make a thorough investigation of the effect of fluoridation on the industries served. If the effect, as determined by scientific studies and not by mere rumor or prejudice, would be

crippling, the water works manager should stop, look, and listen, and should, probably, wait for a clearly authoritative command before going forward with the project. Great caution is indicated if the water supply is used in food processing plants using evaporation methods.

Liability

The most serious fluoridation problem is the possible liability of the water purveyor for damages for personal injuries caused by fluoridation.

The conditions under which, in the author's opinion, liability for personal injuries could be imposed by the governing legal principles can best be developed by setting up a few suppositious examples. In the illustrative situations which follow, it is assumed that fluoridation has been requested by local authorities and dental and medical associations and that the instruments and methods of application have been approved by the department of health. It is also assumed that only the scientific facts now known are available to the water purveyor and that it can be proved that those claiming injury had not subjected themselves to conditions under which fluorides could have affected them from any source other than the public water supply in question.

Two years after the beginning of a fluoridation program it is found that there has been a slight increase in the number of children having mottled teeth; that this new mottling is inconspicuous; and that the proportion of children experiencing dental caries has been significantly reduced. There would be no evidence here to indicate anything other than the anticipated results, and no claim for damages from those developing mottled teeth could be sustained. The legal principle involved comes under the law of negligence. Everyone foresaw the risk of harm to a relatively few individuals but considered that risk outweighed by the utility of the benefit to the greater number in the community. The game was worth the candle in the minds of the community.

In another example, what might be called an epidemic of mottled teeth developed in the service territory. Such an epidemic would certainly result in liability for damages. The result was not anticipated and, under the assumed facts and with present knowledge, could only be caused by human failure. The stronger the scientific arguments for fluoridation, the less chance there is of tracing the epidemic to anything other than a long-continued overdosing of the water with fluorides. It would not be necessary for a plaintiff to prove where, how, or when the overdose took place. The water purveyor would be held liable on one or more legal principles: [1] an implied warranty on the part of the purveyor that the water would not produce the proved conditions; or [2] negligence under the doctrine of *res ipsa loquitur*—that is, the thing speaks for itself. The epidemic could not have developed if the purveyor in sole control had done his duty.

In the final example, several years after the beginning of fluoridation, there was a significant increase in bone cancers, and it is proved that the increase is due to the treatment of the water supply. The author feels that no legal liability would result from a case of this type. While the water treatment program was being conducted, there were no known facts indicating a real risk of such a result. It is true that

opinions have been expressed that some such result might possibly occur, but these opinions have been weighed by scientists and found to be without substance in the light of present knowledge. He who acts is guilty of negligent conduct if he perpetrates an act which a reasonable man should realize involves an unreasonable risk of harm to another. A reasonable man is one who is reasonably considerate of the safety of others. In determining what risks a man should recognize, only those circumstances which he knows, or should know, at the time of his action should be considered. As no one knew that fluoridation would adversely affect the general health at the time the water purveyor took action, the water purveyor did not impose an unreasonable risk on others by engaging in fluoridation.

Conclusion

To reason from recorded cases dealing with typhoid and tainted meat that the courts would hold the water works operator liable for unforeseen results of fluoridation appears to be unsound. Everyone recognizes the deadly danger in water carrying typhoid or in spoiled food, and everyone seeks to avoid such sources of danger. In the examples given, on the other hand, the public authorities and the general public wanted fluoridation—that is the assumption—they knew of no unreasonable risks fluoridation might impose, and they were eager to use fluoridated water. The courts consider legal principles in the light of facts and circumstances, and are unlikely to hold that one who carefully treats water with fluorides is guilty of negligence or breach of an implied warranty if unforeseen injuries result.

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Community reaction to fluoridation of the water supply varies greatly around the country and may even change with time in any one locality. The public may demand fluoridation in community No. 1, reject it in community No. 2, favorably receive it in community No. 3, and stage a political fight over it in community No. 4. Local sentiment on any question is the result of the information made available and the manner in which it is presented, but it may be influenced by the inherent feelings of the individual. The factors affecting public opinion on this important subject are of interest.

Arguments for Fluoridation

Properly to evaluate information on a subject involving scientific principles and affecting the dental health of the individual, the public must know the position taken by health, medical, dental, and scientific organizations. The array of national organizations sponsoring fluoridation is impressive including: State and Territorial Dental Health Directors, American Assn. of Public Health Dentists, American Dental Assn., State and Territorial Health Officers, American Public Health Assn., U.S. Public Health Service, National Research Council, and the American Medical Assn.

The author's data are based primarily on experience in California but should be representative of other areas in which the question is controversial. Organizations at the state level sponsoring fluoridation include: California Dental Society, California Medical Society, California State Dept. of Public

Health, California Congress of Parents and Teachers, and the California Junior Chamber of Commerce which has adopted fluoridation as its project of the year. The California Junior Chamber of Commerce is spearheading the movement in many California communities. In general, the local organizations sponsoring fluoridation are the counterparts of the state or national organizations which have approved the movement.

The usual practice in acquainting the public with the advantages of fluoridation is through letters to the editors, news releases, radio talks, and, sometimes, personal appearances before service clubs and other civic groups. The next step is to sell the program to the appropriate city council, board, or commission through personal contact and by bringing authoritative speakers to regular meetings or special hearings. Experience seems to show it is easier to explain the advantages of fluoride treatment to governing boards than to sell the program to the voters. When the issue becomes controversial, however, men in public office prefer to place the matter before the people. In such circumstances, a popular program now followed is to appoint a "Citizens' Committee for Fluoridation" with representation on the committee from civic, labor, health, medical, dental, and other professional organizations. Public education programs on the advantages of fluoridation are then carried on through the newspapers, radio, personal appearances before groups, and by including arguments in favor of the issue in the printed material mailed to all the voters. A film entitled "A Drop in the Bucket" made by the U.S. Public Health Service and distributed through state health departments, is now being made available for showing to any interested group. Included in the arguments favoring fluoridation are the following (submitted without comment on validity):

1. Research has proved that a fluoride content in the water supply of 1 ppm, either natural or artificially applied, will reduce dental caries approximately 60 per cent as compared to the dental caries rate when the fluoride content is practically zero.

2. Many leading national research and professional organizations have endorsed fluoridation, and, in addition, it has been endorsed by state and local health, dental, medical, civic, and community organizations.

3. There are now approximately 200 cities carrying out fluoridation programs throughout the country.

4. The benefits derived are great in comparison with the small cost involved (5¢ to 15¢ per capita is listed as the annual cost and it is said that $38 will be saved in dental bills for each $1 spent on fluoridation).

5. There is no evidence that consumption of water containing fluoride in the amount of 1 ppm will have any injurious effect on the human body. Three million people have been drinking water containing this much or more natural fluoride for many years.

6. Fluoridation has no healing or curative powers, but is simply a preventive measure to reduce dental caries.

7. Fluoridation does not change the quality of water either for domestic or industrial use and is not harmful in irrigation of lawns and flowers.

8. Fluoridation is similar to chlorination which has been an accepted method of water treatment for many

years, and which was violently opposed when its use was first inaugurated.

9. Five times the present number of dentists are now needed to give people adequate and needed dental care, and therefore, a method of mass prevention of dental caries or mass improvement of dental health must be found. Fluoridation of the public water supply fits the need.

10. This program will improve the dental health of children, particularly the underprivileged, and children are the country's greatest asset.

Opposition to Fluoridation

Opposition to any movement begins only after the movement has started, and the timing of the opposition is a most important factor in its effectiveness. The principal organized group opposed to fluoridation is the Christian Scientist Church. The chiropractors have joined the opposition, and many of the "health food followers" are vigorously opposed to fluoride treatment. One local water works group seems opposed to it, and committees have been formed in localities for the specific purpose of fighting fluoridation.

Included in the arguments used by the opponents of fluoridation are the following (submitted without comment on validity):

1. The issue in fluoridation is not whether fluorides may prevent tooth decay in children, but whether the public water supply can be adulterated, and, at the same time, a precedent be established for compulsory state medicine. If the water department is required to put fluoride in the water today, they may be prevailed upon to use the water supply as a medium for adding other materials for bodily treatment at a later date.

2. Fluoride is a poison and is injurious when taken even in small amounts.

3. There may be harmful effects from the program about which no information is now available. Experimental programs have been in effect only seven years and, therefore, sufficient data have not yet been gathered.

4. Fluorides cause mottling of the teeth, embrittlement of the bones, cancer, and kidney diseases.

5. Fluorides in small amounts are injurious to plant and animal life; therefore, many plants and pets would not survive.

6. Less than 1 per cent of the treated water would be consumed for drinking purposes and only 20 per cent of this amount would be effective in reducing tooth decay. Therefore, the method is uneconomical, for most of the chemical would be wasted.

7. There are mediums better suited for distributing the fluoride, such as milk, bottled water, salt, or fluoride tablets. No chemical would be wasted and fluoridation could be a matter of individual choice.

8. Fluoridation is mass medication, and there are many people who will object because of its conflict with their religious convictions.

9. Fluoridation of the public water supply is a violation of fundamental liberties. It is un-American and could interfere with medical as well as religious freedoms.

10. Fluoridation of the public water supply is illegal.

11. Finally, a rumor is being circulated that fluoridation is a diabolical plot, originated under communistic influence to mass poison the American people, effecting a destruction of their will to resist communism.

Speakers for the opposition also appear before governing bodies, discuss the matter personally with officials, make personal mailings of data, and use the newspapers and sometimes the radio to present their views to the public. Many of these people are most sincere and feel they are performing a public service. Their arguments, regardless of validity, are often very effective, for they arouse doubts in the minds of many people about the propriety of giving fluoride treatment through the public water supply, or about the absolute safety of the program. In either event, the net result may be opposition to the program or a "No" vote if an election is held on fluoridation.

Jerome C. Zufelt

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There are several obvious ways of financing the costs of a fluoridation project. The happiest arrangement would be for a utility to be in such good financial shape that it can absorb the cost with no further ado. Frequently the utility can absorb the cost, but in many communities a compensating adjustment must be made in the rates.

In Sheboygan, Wis., fluoridation was undertaken as a program of the local board of health. The idea was new and there was little precedent to follow. The city attorney raised the question of the possible liability of the water department if someone took exception to the fluoridation program and sued for redress because of illness or religious or other objections to the program.

A municipally owned water utility has been determined to be a proprietary function of a municipality having much the same status in law as a private corporation. A suit based on the right to treat the water would have to be defended on its merits by such a corporation. The city in its governmental function, however, with broad powers to carry out health measures, acts as a shield or buffer to the water utility.

The attorneys, therefore, wrote an ordinance so that the fluoride program was made a governmental function under the city health department. To satisfy the legal requirements of the definition of principal and agent, the cost is borne by the city general fund, not the water utility funds.

The portion of the fluoride ordinance pertaining to financing states:

> Section 2. Insofar as the facilities, equipment, plant, and employees, subject to the jurisdiction of the Board of Water Commissioners of the City of Sheboygan, may be needed and used in connection with this public health program, they shall be so used in this project as facilities and agents of and for the City of Sheboygan as a Municipal Corporation of the State of Wisconsin.
>
> Section 3. The cost of the materials, equipment, and labor for such purpose shall be paid out of the General Fund of the City of Sheboygan by the proper officers upon presentation of itemized, verified claims therefor.

The water department was reimbursed from the city general fund for the purchase of the feed machine and its installation. Each year the utility submits its bill for the fluoride purchased during the year, maintenance and operation of the feeder, and respirators and gloves that have been re-

quired. As no additional help has been hired for the program, and as the actual time involved in filling and tending the feeder is negligible, no charge is made for labor.

In June 1949 the state legislature (1) enacted a measure which permits municipalities to include the cost of fluoridation in the charges for water service. At the same time another provision was added to the statutes requiring the Public Service Commission to include the cost of fluoridation in authorized water utility charges when rates are established and approved.

A good argument can be made for payment by the health fund from taxes, because the benefit is entirely to health and has no relationship to the extent of water consumption by a customer, particularly commercial and industrial users. On the other hand, fluoridation cost will usually constitute less than 2 per cent of gross income, so that including it in the water charges would not increase rates appreciably. A proper way to increase rates for fluoridation would seem to be the addition of the entire cost to the first step, the service charge or minimum charge step, where it would be paid almost entirely by the residence consumer who benefits, and not by the large commercial or industrial user. In Sheboygan, this plan would increase the quarterly first step from $1.35 for a ⅝-in. meter including 600 cu ft of water to $1.48, or $0.13 per quarter.

Reference

1. Wisconsin State Legislature. Section 66.069 (1) (a) (1949).

Correction

In the "Minimum Standards for Design, Construction, and Maintenance of a Public Water Distribution System" prepared by the Michigan Section AWWA which appeared in the May 1952 JOURNAL, incorrect specifications were given on page 378, Section 3.2.7. Instead of referring to C202 and C203, the last sentence in this section should be amended to read:

> Coal-tar enamel protective coatings for steel pipe shall conform with AWWA C203 for pipe 30 in. and over in size, and AWWA C204 for pipe smaller than 30 in.

Simplified Procedures for Collecting, Examining, and Recording Plankton in Water

By William M. Ingram and C. Mervin Palmer

A contribution to the Journal by William M. Ingram, Biologist, Ohio-Tennessee Drainage Basins Office, Div. of Water Pollution Control, and C. Mervin Palmer, Biologist, Environmental Health Center, Public Health Service, Cincinnati, Ohio.

WATER treatment plant operators are becoming increasingly interested in a regular program of checking their water supplies for taste- and odor-producing organisms and for those organisms which interfere with water treatment. Uniform and adequate records are essential if such analyses are to be of value. Simplified procedures for collecting, examining, and recording plankton are presented here in the hope that they will promote the accumulation of uniform, comparable data by water works men who are making plankton counts as an adjunct to standard, routine water analyses. Water works personnel attending training courses at the Environmental Health Center in Cincinnati, Ohio, have expressed an interest in, and a need for, such information.

The term plankton as used herein refers to those minute unattached animals and plants, exclusive of bacteria, that require at least the standard low power of a compound microscope for identification. For practical purposes the term includes, in addition, the microorganisms which develop originally as attached forms but break loose to become a part of the drifting population. Among the plankton are certain algae —*Aphanizomenon, Volvox, Anabaena, Microcystis* (*Polycystis*), *Dinobryon, Synedra, Synura, Asterionella,* and animals that may be associated with them —*Cyclops, Daphnia, Bosmina, Hydra,* and *Planaria.*

Water treatment plant problems produced by plankton include tastes and odors in the raw or finished water, the clogging of filters necessitating frequent backwashing, discoloration, and excessive turbidity of the water, the presence of surface scums or slimes, and attached growths which break off to form floating mats of vegetation. In addition, some workers have suggested that algae or their byproducts may be related to outbreaks of gastroenteritis in humans.

There are numerous publications dealing with the detection and control of those microorganisms inimical to the provision of a potable water supply, and some pertinent contributions to this aspect of the microbiology of water treatment may be listed (1–9).

Record Significance

The value of a continuous and accurate record of the plankton has been demonstrated at water plants, where it has enabled the water plant operator to detect a potential "bloom"—a concen-

tration of floating microorganisms dense enough to be seen with the naked eye—and to destroy it before development of tastes and odors or filter clogging. Because of the regular weekly counts and records made by the plant biologist, C. E. Taft, the late C. P. Hoover of the Columbus, Ohio, Water Treatment Plant was alerted to potential blooms on Griggs Reservoir and destroyed them before they could reach concentrations sufficient to produce trouble in the plant. When counts of certain microorganisms rose to a point which, for Griggs Reservoir, indicated the beginning of taste and odor production or filter clogging trouble, copper sulfate was immediately dispersed in the waters to control the algae before a bloom developed. In this way, microorganisms were controlled at a fraction of the expenditure which would have been required if a bloom had developed and tastes and odors had reached the treatment plant (1, 2).

Any data, biological or otherwise, must be adequate if they are to be of value. Isolated microscopic examinations of water are generally of little use. Regular weekly examinations, even if somewhat superficial, will usually give more valuable information on what is happening to plant and animal populations than will samples taken on three or four consecutive days of a month. Weekly samples will indicate the trend of plankton populations, whereas samples taken once a month will be too far apart to show this trend and will allow populations of plants and animals to gain headway and to cause trouble in the plant.

When the usual population trends for the more significant organisms have been determined, modifications in the sampling schedule can be made to provide better coverage—for example, if experience shows that forms such as *Aphanizomenon* cause trouble during August and September, microscopic examinations of water can be made every two to three days during that period because it is known that this alga is capable of producing sudden blooms, and the weekly samples might miss the early stages. This more frequent sampling would permit the operator to institute control measures in a settling reservoir or other impounding basin and thus avoid coping with a much larger population of the organisms a short time later in the filtration plant itself. When records have been kept over a period of several years, the potentially dangerous periods can often be determined and special examination periods arranged in advance. Thus, the weekly data sheet eventually serves as a weather map that may permit the forecasting of a deluge of organisms and so enable the water plant operator to raise his umbrella before he is soaked!

Records plotted over several years will also give the operator a general knowledge of the specific kinds of algae and other microorganisms comprising the population of the water. Eventually, the seemingly difficult task of learning the identity of the organisms that are the offenders and of finding time in an already crowded schedule to develop additional data sheets will produce results which make the effort worthwhile.

Two factors have often deterred operators who recognize the value of continuous uniform records of the populations of microorganisms in the water: how to determine the identity of the organisms seen through the microscope, and how to establish adequate record sheets to set a standard for the local water supply.

Plankton Identification

Lackey (3) has written an interesting and enlightening, though technical, article on the identification of plankton for the water plant operator. The well-prepared guide by Needham and Needham (4) as well as a few more complete references such as those by Whipple, Fair, and Whipple (5) and by Smith (6) are helpful. In addition, there are many small colleges as well as the larger universities with staff members in biology departments who are willing to aid water plant operators in the initial identification of organisms. After the operator becomes familiar with the chief offending microorganisms in the local water supply through consulting guides and university or college scientists, the work of identification may become routine and more or less automatic.

Plankton Record Sheet

An early problem in plankton studies is that of preparing plankton record sheets that are adequate to establish a standard for the local water supply. The record sheet should be sufficient for all necessary data but should not call for the complicated and detailed records that only an expert biologist could be expected to prepare. A suggested record sheet (Table 1) of this sort has been prepared especially for operators of water treatment plants. If the treatment plant has a consulting biologist on its staff, a sheet calling for more details and more readings might be desirable.

The simplified record sheet has four main sections: the top section is for information useful in classifying or filing the sheets; the middle section is reserved for recording the results of the examination, including the total count and the differential count by organisms, and may be varied in length to accord with local needs and stationery size; the lower left hand section is for information to be supplied by the collector at the time the sample is obtained; and the lower right hand section is for information supplied by the examiner who analyzes the sample.

The Collector's Record

The sampling place or station should be listed on the record sheet. The same sampling station should be used regularly in order to eliminate variations resulting from different sites. If several points are to be sampled in an impounding reservoir, they should be clearly indicated with code letters or symbols on the record sheet and the exact location should be noted in the files so that others may check the collection points in succeeding years.

As microorganisms vary in number and kind at different depths, one or two standard sampling depths should be established and recorded on the record sheet. If samples are taken at Stations A, B, and C at depths of 15, 20, and 2 ft, respectively, the results are not comparable. In the same way, samples taken at different depths at the same station may vary considerably in their composition. It is recommended, therefore, that the 1- and 15-ft depths be established as standard for samples from these depths should adequately represent the plankton population under normal conditions. In shallow reservoirs, 5 or 10 ft may have to be substituted for the 15-ft depth.

It is important to note the time of day at which collections are made. Plankton populations will fluctuate during a period of 24 hr, even exhibiting changes in abundance every few hours. In order to secure more comparable

TABLE 1

Plankton Record Sheet

Sheet No.....

.....Water Treatment Plant

PLANKTON RECORD

Sta.....Depth of Sample.....Date Collected.....Hr.....

Organisms	Fields Examined										No. Organisms in 10 Fields	No. Organisms per ml	No. Organisms per gal
	I	II	III	IV	V	VI	VII	VIII	IX	X			
Total Count													
Differential Count													

Collector's Information

1. Collected by:.....
2. Water Temperature:.....
3. Weather: (Clear, etc.).....
4. Vol. of Sample Collected:.....
5. Preservative (Kind & Amt.):.....
6. Condition of Water & Plant System.....
   a. Algal growth on reservoir wall:.....
   b. Clogging of filters:.....
   c. Dead fish:.....
   d. Odor in raw water:.....
   e. Odor (& taste) in finished water:.....
   f. Surface scum:.....
   g. Turbidity (raw) water:.....
   h. Other conditions:.....

Examiner's Information

7. Analyzed by:.....
   Date:.....19.....
8. Method of Concentration:.....
9. Volume of Sample & Concentrate.....
   a. .....ml of sample filtered
   b. .....ml of final concentrate
10. Conversion Factors to:
    a. No. organisms/ml.....
    b. No. organisms/gal.....
11. Significance of Organisms Found:
    .....
12. Treatment Recommended:
    .....
    .....

samples and to take advantage of the peak in algal cell populations, which are generally more abundant during strong sunlight than during early morning haze periods, samples should be collected between 1 and 3 o'clock in the afternoon.

In the lower left hand section of the record sheet space is provided for recording water temperature and weather conditions. Water temperature and sunlight directly affect the growth of algae. Changes in these environmental factors will forecast changes in the plankton population. Other factors such as turbidity and pH might be added to the plankton record chart if they are not included in the chemical-physical record charts already in use.

A 500-ml sample is recommended for most reservoirs because it is sufficient to show adequately the population of those microorganisms that are important to the operator of the water treatment plant. Frequently it is not convenient to concentrate and examine samples immediately after collection. Because many of the organisms change or even disintegrate soon after collection, it is advisable to add a preservative if the samples are not to be examined at once. The simplest and usually the most satisfactory preservative is concentrated formaldehyde solution, 30 to 50 ml per liter of sample, which makes a 3 to 5 per cent solution. Data on preservation should be recorded on the plankton sheet. Alcohol is not satisfactory as a preservative for algae because it extracts the pigments from the microorganisms, making them more difficult to identify.

The sample collector should carefully observe conditions at the time the samples are taken. He should be alert to note and record any unusual happenings. A typical statement, for example, might read: "stream leading to impounding reservoir was flushed last night carrying debris and large masses of green surface growth into the reservoir," or "water level of reservoir 3 ft below that of last week, leaving masses of dried algal scum exposed on reservoir wall."

Plankton Count

Before preparing the plankton record sheet, the operator assigned to plankton counts should familiarize himself with the flora and fauna of the local water. As a starting point, in order to make the initial task of identification easier, he should check the illustrations of the troublemakers given by Whipple, Fair, and Whipple (5) and Hale (7) before turning to the microscope, to become familiar with them as ideally pictured. He should then collect samples from various areas for study. These samples can be concentrated by the Sedgwick-Rafter method or by the centrifuge method as outlined in *Standard Methods for the Examination of Water and Sewage* (8). Samples can be taken from such a concentrate with a pipet or eye dropper and placed upon a microscope slide for examination and identification under both low and high magnification. This practice will soon give the operator a general idea of the organisms that he may encounter.

The time consumed in counting procedure to be practical for the water should be kept to a minimum for the plant operator. The authors recommend that the number of fields counted, as delimited by the Whipple ocular micrometer, be limited to ten per sample. A statistical analysis of plankton counts by Moore (9) indicates that ten is the minimum number of fields which can be used to obtain reasonable accuracy.

The ten fields must be selected with care if they are to be representative. The authors recommend the following counting method: Place the Whipple ocular micrometer on the diaphragm in the microscope ocular. Fill the Sedgwick-Rafter cell (Fig. 1) with the sample to be examined and place it in position on the stage of the microscope. In selecting the location of the first field to be counted, look through the microscope and place the Whipple ocular micrometer over the Sedgwick-Rafter cell approximately 7 mm down from its upper right hand corner, just within the boundary of the cell. From this starting position, follow a horizontal coordinate across the Sedgwick-Rafter cell; count the first field after moving the cell approximately 5 mm along the horizontal plane, then move approximately 10 mm and count the next field in view. By allowing approximately 10 mm between fields counted, five fields will be recorded across the counting cell. For the other five fields, repeat the procedure approximately 7 mm from the lower margin of the cell. A mechanical stage on the microscope, although not required, would facilitate the selection of the fields to be counted.

It is necessary to enumerate every organism observed, including those which the examiner cannot identify. Each type of unknown organism should be given a symbol or temporary label to make it easier to interpret the results when and if the forms are identified at a later date. The most important unknowns are those which have some resemblance to the troublemakers.

For enumeration, the authors recommend a straight numerical count, 1, 2, 3, rather than the areal standard unit or the cubic standard unit. In using the areal or cubic unit count the operator is sure to run into difficulties in estimating the dimensions of every organism observed and in finding a correct factor to use in changing a numerical count to the areal or cubic unit count. The numerical count is quantitatively accurate and can readily express a danger point in terms of numbers of organisms present while areal units are rather vague and do not give a true conception of the number of organisms.

The numerical count is similar to the clump count employed by bacteriologists in making direct microscopic counts of milk. A clump is a single cell or colony of cells which is seen under the microscope as an isolated

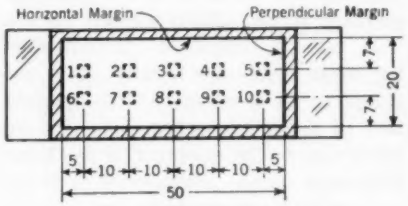

Fig. 1. Sedgwick-Rafter Cell

The fields to be counted are numbered 1 to 10. All dimensions are in millimeters.

unit. Thus a *Diplococcus* clump containing two cells would be listed as one unit of *Diplococcus* in the count and a *Streptococcus* clump containing eighteen cells would be counted as one unit of *Streptococcus*.

When organisms are located across the marginal line of the Whipple ocular micrometer in any field, those crossing the top and the left side should be counted while those crossing the right side and the bottom should be omitted.

A total count of all the organisms should be kept as well as a specific or differential count of the various kinds of plankton organisms. When organisms cannot be identified and are listed under titles such as Unidentified A, B,

C, a brief description and possibly a rough sketch of each should be placed on the back of the sheet. Later, when names for some of these unidentified organisms have been obtained, the older records can be made more intelligible.

After the count is completed the operator can, by calculation, establish for his plant an extrapolation from the ten Whipple ocular micrometer fields to number of organisms per milliliter, number of organisms per liter, or number of organisms per gallon. The following formula will give the multiplier factor for converting the count of ten fields to number of organisms per milliliter:

$$\frac{\text{No. of fields in Sedgwick-Rafter cells}}{\text{No. of Sedgwick-Rafter fields examined}} \times \frac{\text{ml of concentrate}}{\text{total ml filtered}} = \text{multiplier.}$$

To obtain the number of organisms per gallon, the number of organisms per milliliter is multiplied by 3,785.

Few quantitative data are available on the number of plankton organisms present in water supplies. Plant operators can make valuable contributions to the literature of water treatment by collecting and publishing data on plankton populations and particularly on the numbers and kinds of organisms present when taste and odor problems arise or when filters clog.

Additional Data

The plankton record sheet should constitute a permanent record to be kept on file for reference when comparing conditions during a similar period in other years. For this reason, as well as for checking on possible mistakes in extrapolation, the name of the examiner, the method of concentration, the volume of sample and concentrate, and the conversion factors should be recorded.

Once a method of concentration is adopted it should be used exclusively, as variations will occur in the counts obtained on samples even from the same collection if they are concentrated by different methods. No method of concentration has been developed which is ideal in all respects—for example, some of the lighter organisms such as the alga, *Aphanizomenon*, tend to spill out over the top of the Foerst centrifuge and are lost, whereas the sand in the Sedgwick-Rafter funnel effectively holds this alga; on the other hand, some diatoms tend to pass through the sand filter but are held by the centrifuge.

The numbers and the kinds of organisms present, when compared with previous records, and the information given by the collector should suggest to the examiner the significance of the organisms found and a recommended treatment. Chemical data on the water supply, a knowledge of the physical layout of an impounding reservoir, and data on the simplified plankton record sheets will aid the water plant operator in devising methods for preventing plankton troubles rather than having to fight the problem itself later on.

The operator's written record of treatment used and results obtained will be invaluable to the examiner of the plankton samples for interpreting his results and in making recommendations for future treatment. The operator's report might be placed on the back of the record sheet and could include, for example, such statements as:

1. Increased activated carbon from ..... to ..... lb.
2. Treated impounding reservoir water with copper sulfate ..... lb.
3. Increased alum at intake pipes leading from river into settling basins from ..... to ..... lb.

4. Bloom of algae in north end of reservoir completely disappeared 24 hr after copper sulfate treatment.

Each person responsible for recording data on the record sheet should sign the sheet in the place provided in order to facilitate evaluation of the information at a later time. When record sheets are examined over a period of years, much will often be revealed by the signature—for example, a man making examinations of samples over five, ten, or twenty years, should become quite expert in comparison to one who substitutes occasionally or one whose signature shows on the sheets for a period of only six months. The personal element cannot be completely eliminated in this type of work. Continuity in service at a specific water plant definitely gives the operator making the counts a better understanding of the problems than would a short period.

The authors feel that the complete and regular use, on not less than a weekly basis, of this simplified plankton record sheet will provide the operator with a fairly complete picture of the biological conditions affecting the water supply with which he is so closely concerned. A more scientific basis upon which to attack such problems as taste and odor, clogging of filters, growth of algae on reservoir walls, and the accumulation of algal slimes on the surface of the water should be provided by accurate, regular records of the plankton organisms in the water supply.

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References

1. Taft, Clarence E. The Algologist and Water Sanitation. Ohio Jour. Sci., **45**: 97 (1945).
2. ———. The Algologist's Part in City and Industrial Water Supply Problems. *Limnological Aspects of Water Supply.* Am. Assn. Advancement Sci., Washington, D.C. (1949), p. 74.
3. Lackey, James B. Identification of Microorganisms in Relation to Water Purification. Jour. AWWA, **34**:1559 (Oct. 1942).
4. Needham, John G., & Needham, Paul R. *A Guide to the Study of Fresh-Water Biology.* Comstock Publishing Co., Ithaca, N.Y. (4th ed., 1941).
5. Whipple, George C.; Fair, Gordon M.; & Whipple, Melville C. *The Microscopy of Drinking Water.* John Wiley & Sons, New York (4th ed., 1948).
6. Smith, Gilbert M. *The Fresh-Water Algae of the United States.* McGraw-Hill Book Co., New York (2nd ed., 1950).
7. Hale, Frank E. *The Use of Copper Sulphate in Control of Microscopic Organisms.* Phelps Dodge Refining Corp., New York (1950).
8. *Standard Methods for the Examination of Water and Sewage.* Am. Public Health Assn. & Am. Water Works Assn. New York (9th ed., 1946).
9. Moore, Edward W. The Precision of Microscopic Counts of Plankton in Water. Jour. AWWA, **44**:208 (Mar. 1952).

Photometric Methods in Water Analysis

By Eugene M. Diskant

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PHOTOMETRY is defined as the measurement of the intensity of light, and it includes visual colorimetry, filter photometry, spectrophotometry, flame photometry, turbidimetry, fluorimetry, and other specialized branches. The first three techniques are used extensively in water analysis because of their speed, convenience, and sensitivity.

Nevertheless, the application of these methods is not as simple as is sometimes pictured. A discussion of the principles involved and of some of the available techniques may aid the analyst in avoiding pitfalls and in obtaining the maximum accuracy that is possible with the equipment at hand.

In recent years, a considerable number of books and papers has been published on the pratical and theoretical aspects of photometric methods of analysis, reflecting an increasing use of, and interest in, such methods throughout the field of chemistry. Annual reviews have been appearing in *Analytical Chemistry* since 1949 (1–4). In addition to the other references given in this paper, the publications of Mellon (5, 6), Gibson (7), Kolthoff (8), West (9), Vredenburg (10), Gibb (11), and the American Society for Testing Materials (12) will be found useful as general references.*

Analytical Procedures

A typical analytical procedure based upon a photometric method may consist of four operations: [1] collection of a water sample; [2] pretreatment of the sample to remove suspended matter or interfering substances; [3] treatment with one or more reagents to develop a color by reaction with the constituent which is to be determined; and [4] comparison or measurement of the colored product, directly or indirectly, against standards.

In order to obtain valid results, each of the four operations must be conducted properly—for example, the supply must be sampled in a representative manner, and the sample must be protected against deterioration because it may be subject to bacterial action, plankton growth, "plating out," and contamination by matter dissolved from the container. It is common to find that filter paper adds or adsorbs constituents. Glass can contribute sodium, calcium, or silica to, or remove heavy metals from, a solution. Bakelite caps have been known to add phenolic compounds to a sample. It should always be borne in mind that glass, filter paper, and soil—that is, sediments—have ion-exchange properties. Sediments initially present in the sample or formed on storage may contain some of the constituent that is sought. Unfortunately, *Standard Methods for the Examination of Water and Sewage* (13)

* After this paper had been set in type, two additional references (37, 38) were brought to the author's attention.

does not always state clearly whether a sample may be, shall be, or must not be, filtered before analysis; individual practice differs in various laboratories. Adsorption and leaching are most troublesome in the work with low concentrations that occurs in water analysis. In the actual analytical procedure itself, addition or removal of the desired constituent must be avoided or minimized. The blank determination corrects for the unavoidable presence of the sought constituent in the reagents employed. The color-development step must result in the production of a color which is sufficiently stable to permit measurement, sufficiently reproducible to permit the desired degree of accuracy, and sufficiently specific to avoid interference from other constituents which may be present simultaneously. Finally, the color comparison or measurement must be carried out under conditions which permit the desired accuracy to be achieved. A complete discussion of any photometric analytical determination must include the problems of sampling, storage, pretreatment, and color development, although the only strictly photometric activity is the final problem, color development, which involves the comparison or measurement of the color.

It is well to emphasize that no photometric method can be any better than the chemistry behind it. Thus, it is of little avail to measure a transmittance with 0.01 per cent precision if the preceding steps have introduced an inherent uncertainty of 5 per cent. The chemistry of photometric procedures has been rather thoroughly discussed by Mellon (14, Chapter 1) and by Sandell (15, discussion of individual procedures). This paper emphasizes the protometric step of the procedures.

Light and Color

Color is a sensation which is experienced when certain wave lengths of electromagnetic radiation strike the eye. The hue represents the name of the color, and the intensity represents its strength or depth. Most people see light if the wave length of the radiation lies within the approximate limits of 400 and 700 mμ (1 mμ equals 10^{-7} cm). Visual colorimetry is, of necessity, confined to this spectral region. Many spectrophotometers are also capable of measuring radiation in the invisible wave length regions below 400 mμ—ultraviolet—and above 700 mμ—infrared.

White light can be broken up into a spectrum containing the visible colors by means of a prism or a grating and conversely, these colors can be recombined to produce white light. White light, therefore, is a mixture of visible wave lengths.

A colored object appears colored because, when it is examined in white light, it reflects or transmits more of the light in certain regions of the spectrum than in others. A white object is one which diffusely reflects or transmits the visible wave lengths without noticeable discrimination; snow is an example. An object which reflects without diffusion is called specular. Mirrors and other highly polished metallic surfaces are examples of specular objects. Objects which transmit the visible spectrum without noticeable discrimination or diffusion are said to be colorless and transparent; water in thin layers is an example. A black object, such as soot, neither reflects nor transmits a noticeable proportion of the light which strikes it. A gray object transmits or reflects a portion

of the light which falls upon it without noticeable color discrimination.

Whether consciously or unconsciously, the colors of the everyday surroundings are referred to daylight. The difficulty of matching fabrics under artificial light is common experience, as is the ghastly appearance of human skin under mercury-vapor or sodium-vapor illumination. The reader is urged to convince himself by direct personal experiment that color—the subjective impression—depends upon white light. If a bright red object, a bright green object, a dazzling white object, and a "dead" black object are taken into a darkroom and examined under a red light, the black object and the green object will both look black and will be nearly indistinguishable, and the red object will appear to be white or gray, very much like the white object. If the experiment is continued by replacing the red illumination with green illumination, the red object and the black object will both appear black, and the green object will look white or gray, very much like the white object. Therefore, it may be concluded that if the illumination consists of light of a single color only, objects examined under such illumination will not appear to have a spectral color, but will range in appearance from white through shades of gray to black.

Certain regions of the spectrum are associated with corresponding colors—the spectral colors. The eye blends together the light which is reflected or transmitted by an observed object in such a way as to produce a single subjective color sensation, however. Many combinations of wave lengths and intensities may produce what the observer considers the same color. As Snell and Snell (16, page 10) point out, a sodium flame and a dandelion flower appear almost the same in color although the sodium flame has more than 99 per cent of its visible radiation concentrated at a single wave length, 589 mμ, and the dandelion flower reflects light over a broad wave length region. Certain artificial color standards exhibit differences in apparent color with changes in the conditions of viewing or of illumination. If an artificial (permanent) color standard for the determination of iron by the thiocyanate method (13, page 55) is placed side by side with the real (temporary) iron standard which it imitates, if both liquids are contained in similar Nessler tubes, and if the observer looks down the lengths (axes) of the tubes toward a source of white light, his subjective impression is that the colors match. If the two tubes are compared by sighting across their diameters, however, the colors (hues) do not match. If various kinds of illumination are tried, it is found that the real and the artificial standards match under some conditions but not under other conditions. Therefore, such artificial standards must be adjusted against real standards under exactly the same conditions that will prevail when the artificial standards are later used for the analysis of samples. The lengths of the tubes and the kind of illumination must be kept constant. A noticeable difference will be observed between sunlight at noon and sunlight at sunrise or sunset. Even if exterior conditions are held constant, a set of artificial standards adjusted by one analyst may not appear to be a perfect match to another analyst because of personal differences in color sensitivity. Artificial standards should be used

only for visual comparison work, never for standardizing a photoelectric instrument.

There are two kinds of color matches: [1] those in which the transmittance or reflectance curves, as determined with a spectrophotometer, are identical and which, therefore, will be visual matches under all conditions; and [2] those in which the spectrophotometer reveals differences, as in the example of the artificial iron standard, and which consequently will match visually only under special conditions. This fact was vividly emphasized during a recent symposium on color measurement (17) at which the following dialogue took place:

MR. MORSE: . . . color matches . . . are made customarily under one type of illumination, which is usually considered as north daylight or its equivalent. So, considered just on that one basis, it is possible to have perfect visual matches and yet have different spectrophotometric curves.

MR. GRANVILLE: They may be slightly different or may be greatly different?

MR. MORSE: That is right.

MR. GRANVILLE: You mean then that you can have a whole series of panels which look the same to the eye and yet have different spectrophotometric curves?

MR. MORSE: That is right.

Disregarding momentarily the discrepancies between the eye and the spectrophotometer, the data of Table 1 indicate approximately the relations between the wave-length region transmitted by a solution, the visible color of that solution, and the color complementary to the visible color. The complementary color corresponds to the color of the light that is most strongly absorbed by the solution. The spectral colors continuously merge one into the next, so that it is impossible to set exact wave-length limits for each color. Moreover, different individuals will set these limits at slightly different wave lengths, including the extreme limits of visibility. Table 1 does permit a first rough approximation of the best choice of a filter or a wave length for photometric measurement when no other data are available. In general, the best choice is that filter or that wave length which is most nearly complementary to the color that is to be measured. The additional factors to be considered are discussed in a later section of this paper.

TABLE 1

Color Transmission and Absorption at Various Wave Lengths

Wave-length Region Transmitted mμ	Visible Color of Solution*	Complementary Color†
Below 400	none (ultraviolet)	——
400–430	violet	yellow-green
430–480	blue	yellow
480–490	blue-green	orange
490–575	green	red
575–590	yellow	blue
590–650	orange	blue-green
650–700	red	green
Above 700	none (infrared)	——

* Color transmitted by solution.
† Color absorbed by solution.

Photoelectric Instruments

In any photoelectric instrument, the photocell generates an electric current which varies as some function of the intensity of the light which strikes it. This current is measured on a meter or a dial, either directly or after electronic amplification, or is balanced with a dial decade bridge.

Photocells cannot distinguish between colors (hues, wave lengths) as the human eye can. It is therefore necessary to restrict the wave-length region by means of a filter, a prism, or a diffraction grating. If a filter is used, the instrument is termed a filter photometer; if a prism or grating is used, the instrument is termed a spectrophotometer.

The band pass (band width, pass band, or wave band) refers to the broadness of the spectral region which is isolated by the filter, prism, or grating. It is usually impractical to express the band pass numerically, because the transmittance curve slopes very gradually toward zero at the edges of the band, and may never actually reach the zero level. For practical purposes, the half width is often used to describe the quality or selectivity of a filter. The half width is the wave length interval, in millimicrons, between the two sides of a transmittance curve, taken at a transmittance equal to one-half the maximum (peak) transmittance. For example, if the curve between points *A*, *F*, and *B* of Fig. 1 represents the transmittance curve of a filter, the maximum transmittance in this interval is approximately 82 per cent and half the maximum is 41 per cent. The 41-per cent points occur at approximately 375 and 485 mμ. The half width is thus 110 mμ. The specification of half width is helpful as far as it goes, but it does not provide information about the stray light transmitted at wave lengths near the base of the transmittance curve, or in other, possibly distant, regions. The definition of nominal band width of a spectrophotometer is similar to that of the half width of a filter, but there is usually less stray light when a prism or a grating is used than when a filter is used.

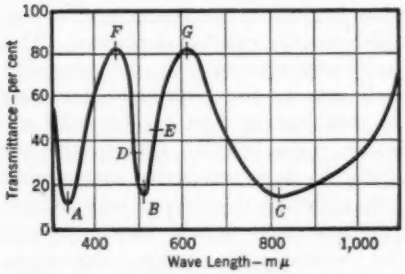

Fig. 1. Transmittance as a Function of Wave Length

The various factors which determine the best choice of wave length are illustrated by a hypothetical absorbing substance. The letters refer to points on the curve.

Until a few years ago, the only filters that were available had relatively broad band passes. Recently, interference filters that have narrower band passes have been commercialized. Interference filters are relatively costly, and if a wide selection of operating wave lengths is required, it may prove to be more economical to purchase a spectrophotometer than to purchase a complete selection of interference filters. For certain special purposes, however, such as flame photometry in which a few wave lengths suffice for all normal needs, interference filters are very economical. Some filter photometers are now sold with a set of interference filters, but such filters will perform according to specifications only when the light beam is itself parallel and incident at right angles to the filter. The operation of other types of filters is not so critical. For many practical purposes, wide band-pass filters will suffice, and are less expensive. The cheapest of the wide band-pass filters are unmounted gelatin Wratten filters which cost less than a dollar each.

Glass filters are more rugged and stable, and cost several dollars each.* Filters differ widely in quality—band pass or selectivity—and there is no way of judging the band pass by visual observation.

The band pass of a spectrophotometer depends upon its optical system. It may be broad, narrow, or variable at the will of the operator but, generally, it can be narrower than that of the older types of filters. The best interference filters, however, provide a narrower band pass than the lowest priced spectrophotometers. The employment of a narrow band pass is advantageous because it results in greater sensitivity and selectivity, and is in closer conformance to Beer's and Lambert's laws than is the employment of a broad band pass. These factors are explained later.

In addition to having a narrower band pass than a filter photometer, the spectrophotometer has the further advantage of a continuously variable wave length. The effective wave length of a filter photometer can be varied only in jumps, by replacing one filter with another.

Interaction

The effective wave length of a broad band-pass filter will depend somewhat upon the sensitivity curve of the photocell and the emission curve of the light source. The barrier type photocell, for example, has a roughly parabolic sensitivity curve and the cell is most sensitive in the yellow and green regions of the spectrum, and relatively insensitive in the red and violet regions (similar to the human eye). If a red filter is used in conjunction with such a cell, the effective wave length of the combination may be shifted from that of the filter by itself, as determined with a spectrophotometer, to some shorter wave length. In simple terms, if the red filter transmits some orange light, the photocell will emphasize the orange light simply because the photocell is more sensitive to orange light than it is to red light. With a barrier type cell, it is possible to employ a red filter which has no cutoff at longer wave lengths in the visible region, but which merely exhibits a plateau. The cutoff characteristic of the photocell itself acts as the limiting factor, and the combination does exhibit some effective wave length. Other types of photocells have sensitivity curves with quite different shapes and may exhibit their maximum sensitivities in almost any wave-length region, depending upon the type of cell. Because of the possible interaction of photocells and filters, published data on filters must not be interpreted too literally.

The narrower the band pass of the filter, the less important are the characteristics of the photocell, because the narrow band pass of the filter tends to become the main limiting factor. Here again, the statement has limitations, because if the photocell has virtually no sensitivity in the region isolated by the filter, it may respond to the small amount of stray light, perhaps unsuspected by the analyst, which the filter may pass in some other spectral region. For similar reasons, data obtained with two different models of instruments will be in better agreement if both instruments use narrow band passes than if one, or both, instruments use wide band passes. The interaction of

* Polaroid Corp., Cambridge, Mass., has announced the manufacture of a "variable color filter" which operates on a different principle from that of ordinary or of interference filters. The new Polaroid filter has not yet been tested for its applicability to filter photometry.

light sources, filters, photocells, and colored liquids has been discussed in greater, and more mathematical, detail by Cooper (18). A convenient collection of data on the older types of filters is presented by Snell and Snell (16, Chapter 12).

Visual Comparators

Perhaps the simplest comparator consists of a rack of Nessler tubes containing a graduated series of standards with which a sample may be compared. A Nesslerimeter * aids comparison by bringing together, optically, the image of the sample tube and the image of any one of the standard tubes. A disk comparator provides a series of colored glasses, mounted in a revolving disk, which serve as permanent artificial color standards. If standards are mounted linearly in a sliding panel, the instrument is termed a slide comparator; if they are mounted on a revolving wheel, a roulette comparator. In a Duboscq type comparator, only one real or artificial standard is used, but the light path is variable to permit matching, and an optical device brings together the images of sample and standard.

Comparative Advantages

There has been some controversy on the subject of whether visual or photoelectric instruments should be employed in water works laboratories. During the past twenty years the trend in the field has been toward photoelectric instruments. Both types have a place in water analysis, for each has special advantages. Although the trend will continue in favor of the photoelectric type, it is doubtful whether it will ever completely replace the visual type for water analysis.

In tall-form 100-ml Nessler tubes, the light path is 30 cm. It is an advantage to use the maximum possible light path for pale colors, such as are frequently encountered in water analysis, and the 30-cm light path of the Nessler tube has as yet no practical rival. Special cells with extra-long light paths for photoelectric measurements can indeed be purchased, but they require modification of the instrument, are very expensive and fragile, and are difficult to fill and adjust—in short, they are useful only in research work. At least two commercial filter photometers provide practical 15-cm light paths. Most commercial filter photometers and spectrophotometers provide only a 1- to 5-cm path which is adequate for some purposes but not for all the purposes of water analysis.

When a visual comparison is made, an alert technician can often tell whether something has gone wrong because an off-color or a turbidity may be present. Such a warning symptom may be overlooked if a photoelectric instrument is used because such an instrument will always yield some reading, whether meaningful or not. Nessler tubes and other visual comparators are portable and relatively cheap, and may be independent of electric outlets. These features make them particularly attractive for use in the field.

Deviations from Beer's law are of no significance when visual comparisons are made in Nessler tubes (although such deviations are a source of error with the Duboscq type instrument). In certain visual comparisons, such as the Scott-Sanchis fluoride determination and the various mixed-color dithizone methods, the hue changes with the concentration of the substance sought,

* A product of Fisher Scientific Co., Pittsburgh, Pa.

so that the hue rather than the intensity is the characteristic observed by the eye.

Photoelectric instruments are subject to electrical troubles, and in some models the readings may be adversely affected by line voltage fluctuations or weak batteries. The average analyst probably lacks the knowledge of electronics and optics which may be needed to maintain or repair a photoelectric instrument; if so, he may have to rely upon expert assistance or factory servicing. Photoelectric instruments are relatively expensive and fragile, and few are portable. They require a greater degree of operator knowledge and must be connected to an electric outlet or batteries. The use of a photoelectric instrument with enthusiasm instead of knowledge will certainly not insure increased accuracy—in fact, it is easy to visualize conditions under which an experienced analyst who has only Nessler tubes to work with can obtain better results than a novice who uses a photoelectric instrument.

The preceding discussion is not intended to disparage photoelectric photometry, nor to discourage the analyst from purchasing photoelectric instruments. Under the right conditions, and if used with knowledge and intelligence, photoelectric photometry is not only more accurate but also more versatile than visual comparison. But Nessler tubes are much more foolproof than complex instruments can be, and it is incorrect to assume that the installation of photoelectric instruments will automatically, as if by magic, insure either more accurate results or more work output.

Some of the advantages of photoelectric instruments over visual comparison include: [1] less personal bias caused by individual idiosyncrasies, such as partial or complete color blindness; [2] greater accuracy under optimum conditions; [3] independence from lighting conditions of the laboratory; [4] possibility of attaching fluorimetric, flame photometric, nephelometric, and other accessories to some models to permit other types of photometry; [5] possibility of using the invisible regions—ultraviolet, infrared; [6] less operator fatigue; [7] elimination of the necessity for preparing a complete fresh set of standards for every set of determinations; and [8] possibility of correcting for interfering color or turbidity.

Comparative Accuracies

The magnitude of the visual comparison error will depend upon the kind of color, the illumination, the sensitivity, and the training of the observer. For a photoelectric instrument, it will depend upon freedom from drift, portion of the scale employed, and other factors that are based on the quality of the instrument. Furthermore, the analytical error, regardless of the instrument employed, will, of course, include errors of sampling, errors of dilution, reproducibility of the color, fading of the color, presence of interfering substances, and other disturbing factors which are of a chemical rather than a photometric nature. For these reasons, the author sincerely hopes that the generalizations which follow will not be taken out of context. They are not intended as guarantees of performance, but merely as indications.

As a general rule, based on results of many observations, it is estimated that comparisons can be made in Nessler tubes with a precision of from 5 to 10 per cent, in a Duboscq type instrument with a precision of from 1 to 5 per cent, and in a photoelectric instrument with a precision of from 0.01 to

0.2 per cent—provided that each measurement is made under its own optimum conditions. These figures show what may be accomplished, not necessarily what will be accomplished in routine work. It is possible to obtain an analytical result which is 100 per cent or more in error, even with the best instrument, by using the instrument improperly, or by using it under conditions which cannot but introduce errors.

Cost

There are considerable differences among the many photoelectric instruments on the market. They vary in band pass, light path, usable spectral region, available accessories, convenience of use, and freedom from fluctuation. The prices range from approximately one hundred dollars to tens of thousands of dollars. Thus, a large stock of Nessler tubes can be purchased for the price of even the cheapest photoelectric instrument—and the cheapest instrument cannot be recommended. The field is highly competitive, and the purchaser gets just about what he pays for. At 1952 prices, the laboratory director should expect to invest from $300 to $1,300 for a worthwhile photoelectric instrument. It is also within the realm of practicability for an adroit chemist to build his own filter photometer.

The choice of instruments, visual or photoelectric, and the make and model, will depend upon several factors: [1] laboratory budget; [2] present needs and anticipated future needs; [3] skill and knowledge of the laboratory personnel; [4] required analytical accuracy; and [5] need for portability.

Simplified Principles

According to Mellon (1), "The confusion in usage of terms, symbols, and data in spectrophotometry remains unsurpassed by that in any other division of quantitative analysis." Practices differ among nations and among individuals, and the fashion seems to change with the passage of time. In this paper the familiar "per cent transmittance" and "optical density" are used, even though newer terms seem to be in the ascendancy, because the older terms are the ones most often found on instrument dials and in the literature of analytical chemistry. The analyst who refers to the literature must be constantly on guard to avoid misconstruing the data he finds, because of the differences in manner of presentation. In addition to differences in terminology, there are differences in the manner of drawing graphs. The wave-length scale may be linear or it may be logarithmic, values may increase from lef to right or they may decrease, and frequency or wave number may be used instead of wave length. The light intensity is almost invariably the ordinate, but it may be calculated as per cent transmittance, per cent absorptance, optical density, or logarithm of optical density. The more important terms are explained below; others may be found in published tables of photometric terminology (14, p. 83; 19, p. 369; 20, p. 5; 21, p. 26).

Light path, in this paper, means the distance which the light beam travels through the solution under examination, within the optical cell. It is usually expressed in centimeters. Strictly speaking, this term has a definite value only when it is applied to a parallel light beam which travels through an optical cell that has plane-parallel entrance and exit faces. It is less definite if test tubes or other cuvettes with curved (cylindrical) entrance and exit faces are used. The terms cell thickness, cell width, cell depth, cell path,

stratum thickness, layer thickness, optical path, and path length will be encountered in reading the chemical literature and are synonymous with light path as used here.

Monochromatic means one wave length only. The best spectrophotometers are capable of utilizing nearly monochromatic light. Filter photometers produce a light beam which contains a considerable assortment of wave lengths. The narrower the band pass, the closer the approach to monochromaticity, or spectral purity.

Transmittance, expressed as a percentage, is the ratio between the intensity of a given light beam, after it has passed through a solution under examination, to the intensity of that light beam after it has passed, instead, through a blank solution. The two solutions are assumed to be in matched cells and to be measured under constant conditions. If the instrument is first adjusted to read 100.0 per cent transmittance with the blank solution in the beam, subsequent readings will be directly in terms of per cent transmittance. Occasionally, because of inadequate initial light intensity, it may be necessary to set the instrument to some reading lower than 100.0 per cent with the blank solution in the beam. In subsequent readings, the per cent transmittance can be calculated by a simple proportion. Transmission and transmittancy are sometimes used as synonyms for transmittance. Many commercial photoelectric photometers have scales calibrated to read directly in terms of per cent transmittance.

Optical density is the common logarithm of the fraction 100/per cent transmittance. Many instruments now on the market have scales which are calibrated to read either directly in terms of optical density, or in terms of numbers proportional to optical density. The expression of results in terms of optical density simplifies calculations, particularly when corrections must be made for interfering color or turbidity, or when it is desired to compare the results obtained by various procedures, instruments, or light paths. Other terms synonymous with optical density are density, extinction, absorbance, and absorbancy. The term absorbancy is gaining favor at the present time, and may eventually displace optical density in popularity.

A matched set of cells consists of two or more optical cells which are as nearly identical in manufacture as is practical. The light paths of the cells of the set should be the same within the desired precision, as should the transmittances of the cells themselves. The first criterion can be checked by direct measurement with precision calipers, and the second can be checked, preferably at several wave lengths, by comparing photometric readings on distilled water. If the desired precision of measurements is greater than the tolerance of the available cells, corrections can be made by calculations in terms of optical densities—for example, if one cell has a light path of 0.99 cm and the other of 1.00 cm, readings, in terms of optical density, must be multiplied by 1.01 if the blank solution is in the 1.00-cm cell. If, when tested with distilled water, one cell shows an optical density of 0.005 with respect to the other cell, this quantity, 0.005, should be subtracted from subsequent readings whenever the solution under examination is in the cell which shows the higher reading, or added to subsequent readings whenever the blank is in the cell which shows the higher reading.

Lambert's law states that when a parallel beam of monochromatic light passes through a given absorbing liq-

uid, the optical density is directly proportional to the light path. No exceptions are known. Apparent exceptions are caused by departure from parallelism or monochromaticity, or lack of linear response of the photometer. The law is also called Bouguer's law.

Beer's law states that when a parallel beam of monochromatic light passes through a constant light path, the optical density is directly proportional to the concentration of absorbing material in the solution under examination. If this law is strictly interpreted there are no exceptions, but in practice there are many apparent exceptions. The law will not be followed if the chemical reaction which produces the colored (absorbing) substance does not proceed to completion, or if more than one product is produced. In these circumstances, the actual concentration of absorbing substance is not proportional to the concentration of the constituent which is to be determined. Beer's law will fail if the photometer response is not linear or if the light is not monochromatic. The band pass criterion of monochromaticity which is tolerable will vary in practice.

Strong (22) states: "Upon examination, it is realized that few deviations from the absorption law observed experimentally are true deviations, as they result from nonfulfillment of the conditions of application of the law . . . . obviously the deviation is not a failure of the law but of the experimenter in not including the absorption and correct concentrations of all components."

Absorption and Transmission

Technicians and even chemists frequently make mistakes in reasoning about photometric measurements, because they may not be aware of the nature of the process of light absorption. Consider a solution of some absorbing substance which is placed in a cell the light path of which is 1 cm and through which passes a parallel beam of monochromatic light. Assume that when the absorbing solution is compared, using matched cells, with a blank solution, the absorbing solution shows a transmittance of 80 per cent. This means that of the light that falls upon the absorbing solution, the absorbing substance allows 80 per cent to pass through, while 20 per cent is absorbed land converted into heat. [Some of the impinging light is reflected by the walls of the optical cell and some is absorbed by the solvent itself, but these complications can be ignored if the absorbing solution is compared against a solvent blank in matched cells, because these losses are then compensated.] Whether a more intense light source or a less intense light source is used, if the wave length remains the same, the result of comparing the absorbing solution against the blank will always be 80 per cent transmittance. As long as the absorbing solution and the blank solution are compared in matched cells of the same constant light path and at the same monochromatic wave length, the original intensity of the light beam makes no difference. Of course, some arrangement must be made to vary the instrument sensitivity in order to permit readings with increased or decreased light intensities.

If a second matched cell of the absorbing solution is placed in series with the first one so that the parallel, monochromatic light beam must pass through both cells in order to reach the photocell, and if the transmittance of this combination is measured against that of a combination of two matched cells of blank solution also in a series, the total transmittance will be 80 per cent of 80 per cent, or 64 per cent. This

percentage results because, at this particular wave length, each cell of the absorbing solution will pass 80 per cent of whatever light falls upon it. The initial intensity does not matter, and the second solution does not "know" that the light which strikes it has already passed through the first cell. Similarly, if a third matched cell of the absorbing solution and a third matched cell of the blank solution are each added to their respective series, the total measured transmittance will be 80 per cent of 80 per cent of 80 per cent, or 51.2 per cent. Again, the use of blanks and matched cells will compensate for absorption in the blank solution (solvent) and reflections by the various cell walls. If the light path is changed by substituting long cells for combinations of shorter ones in series, obviously the process is not changed; each increment of the absorbing solution will absorb a fraction of the light which is characteristic. For the mathematically minded reader, the preceding discussion may be condensed into a single sentence: the intensity of the transmitted light decreases as an exponential function of the light path and the concentration of absorbing substance.

Because of the properties of logarithms, the relations exemplified above are easier to calculate if optical density rather than per cent transmittance is used—for example, if a particular absorbing solution at a particular monochromatic wave length has an optical density of 0.1 when the light path is 1 cm, it will have an optical density of 0.2 when the light path is 2 cm, and 0.3 at 3 cm.

Beer's law cannot hold, in practice, any better than the chemistry of the color-developing reaction permits. Whenever the reaction which develops the color (absorbing substance) proceeds to completion without complications, the same type of reasoning which was applied to changes of light path can be applied to changes of concentration. If 1 ppm of some absorbing substance, when measured against a blank at some particular monochromatic wave length, has an optical density of 0.1, under the same conditions 2 ppm will have an optical density of 0.2, and 3 ppm will have an optical density of 0.3.

Plotting Data

Conformity to Beer's law is not an absolute necessity for the utilization of a photometric method of analysis, but it is a great convenience. It indicates a favorable chemical system, it tends to make calibration easier and more accurate, and it permits a more accurate correction for interfering color or turbidity. It is easier to draw and read calibration charts if the lines are straight than if they exhibit strong curvature, and fewer points serve to check the validity of a straight line than of a curve. If Beer's law holds, a graph on rectangular graph paper, on which optical density is plotted as the ordinate and concentration as the abscissa, is a straight line. The same advantage is observed if per cent transmittance is plotted on the logarithmic axis of semilog graph paper and concentration on the linear axis.

In many practical analyses, the graphs are straight or only slightly curved lines, indicating conformity to, or only slight deviation from, Beer's law. The per cent transmittance method of plotting has a slight disadvantage—if the numerical value of the optical density is wanted, it cannot be read directly from the graph. It is a very convenient method of plotting, however, if the instrument happens to

be calibrated only in terms of transmittance.

The older practice of plotting per cent transmittance on rectangular graph paper always resulted in curved lines, and sometimes erroneous or even ludicrous conclusions were made about the straight and the inflected or the steep and the flattened portions of such curves. As Ayres (23) states:

> The plotting method [transmittance versus concentration on rectangular graph paper] . . . is probably the most misleading of all the various methods of handling photometric data; a steep curve at low concentration is taken as indicative of good accuracy, as small differences in concentration are easily detected by comparatively large differences in light absorbed . . . however . . . these small concentration differences are on small concentrations; in other words, the error may be small but the accuracy (measured by relative error) may be poor. All colorimetric data plotted as transmittancy . . . against concentration give steep curves at low concentration and flat curves at high concentration, yet the accuracy is highest in the middle range, for in this range a given photometric error produces the least relative analysis error.

Optical density or per cent transmittance may be converted by means of the equation:

$$\text{optical density} = \log_{10} \frac{100}{\text{per cent transmittance}}.$$

A conversion table may be used, or if a dual-scale instrument is at hand, it is very convenient to use its dial as a conversion table.

Accuracy

A photometer is not uniformly accurate over its entire scale (24). At very low transmittances the scale is crowded in terms of concentration, so that a considerable change in concentration produces only a small change in the reading. As an extreme example, consider a solution which has 1 per cent transmittance. If the concentration of absorbing substance is doubled, and if Beer's law holds, the more concentrated solution will have 1 per cent of 1 per cent, or 0.01 per cent transmittance. It will be impossible to estimate 0.01 per cent transmittance on the instrument dial with any degree of accuracy, however. If the dial is graduated in units of 1 per cent, and if the analyst can estimate, by eye, 0.1 of a division, he cannot read closer than 0.1 per cent, ten times 0.01 per cent. Even if the absorbing solution has a transmittance of 1 per cent, the reading error is one-tenth of the value to be recorded. Furthermore, stray light and lack of monochromaticity become more disturbing at very low transmittances. At very *high* transmittances, slight differences in the cells, in the way they come to rest within the instrument, the presence of a slight, perhaps invisible, turbidity, dust, fingerprints, air bubbles, or condensed moisture, may cause an error in the reading which is of the same order of magnitude as the reading itself, again producing intolerable error in the analytical result. In addition, the spread of dial readings with relative change of concentrations is again small, as it is at low transmittances. As an extreme example, consider a solution which has 99 per cent transmittance. If the concentration of the absorbing substance is doubled, and if Beer's law holds, the more concentrated solution will have 99 per cent of 99 per cent, or approximately 98 per cent transmittance. There will be a large relative reading error in interpolating by eye between

the scale calibration marks at 99 per cent and 98 per cent, and a fingerprint or other extraneous dirt, or bubbles clinging to the cell wall, may cause the reading to be—for example—97 per cent instead of 98 per cent. Even upon attempting to duplicate readings, differences of this magnitude may be observed because of slight differences in the way the cells come to rest. In this example, a reading error of one scale division (97 per cent instead of 98 per cent transmittance) produces an analytical error of about 50 per cent. For these reasons, it is just as desirable to avoid readings at very high transmittances as it is to avoid readings at very low transmittances.

Finally, consider readings in a more favorable part of the scale. If a solution shows a transmittance of 60 per cent, if the concentration is doubled, and if Beer's law holds, the more concentrated solution will show a transmittance of 60 per cent of 60 per cent, or 36 per cent. Suppose that, for one of the reasons mentioned, the analyst reads the second transmittance as 35 per cent instead of 36 per cent. This will produce a much less serious relative analytical error than will the error of reading 97 per cent instead of 98 per cent. The error in any particular determination which will result from a given error in reading the instrument dial will depend upon the slope of the calibration curve. The steeper the slope, or the greater the change in optical density per unit change in concentration, the smaller the analytical error.

It can be seen intuitively, and proved mathematically, that at some middle point on the photometer scale the best analytical results will obtain. If only the reading error is considered, it can be calculated (24, 25) that a photometer is most accurate at 37 per cent transmittance. Other factors which vary with the design of the instrument and with the particular color system used in the chemical analysis may cause the calculated point of greatest accuracy to fall at some value other than 37 per cent, and, in addition, the variation of analytical accuracy with transmittance reading error will not be the same for all instruments. It can be stated as a safe operating rule, however, that photoelectric instruments are satisfactory for routine analyses between approximately 10 and 80 per cent transmittance (between approximately 1.0 and 0.1 optical densities). If readings can be confined to the region of 20 to 60 per cent transmittance, so much the better. The closer the readings fall to 0 or to 100 per cent transmittance (to infinite or to zero optical densities), the larger is the relative error that must be expected in the analysis. In general, the error increases faster as the 100-per cent reading is approached than it does as the 0-per cent reading is approached. Values are frequently reported in the literature that were obtained at the expense of known photometric principles—values calculated from readings at the extremes of a photometer scale.

It would be advantageous if some firm were to print special graph paper for the express purpose of making photometric calibration curves. The regions from 100 to 80 per cent and from 0 to 10 per cent transmission could be overprinted with red, meaning stop—danger. The regions from 80 to 60 per cent and from 10 to 20 per cent could be overprinted with yellow, meaning passable—but proceed with caution. The remainder of the paper,

from 20 to 60 per cent, could be left white or overprinted with green, meaning safe.

Some years ago Ringbom (26) published a simple procedure for finding the best range of any photometric method with any available instrument, and determining the analytical error to be expected. His paper did not receive the attention it deserved, probably because it was published in German, until Ayres (23) called attention to it. If per cent transmittance is plotted (Ayres actually plotted 100 minus per cent transmittance, but the result is the same) on the linear axis of semilog paper, and concentration on the logarithmic axis, an S-shaped curve results. The straightest portion of this curve represents the optimum range. It will be noticed that this manner of plotting on semilog paper is exactly the opposite of that previously recommended in this paper. The method described earlier produces a straight, or nearly straight, graph, very convenient for reading and easy to check, but it gives no inkling of the expected accuracy. The method of Ringbom, revived by Ayres, produces a curved graph, inconvenient for calibration purposes, but it does provide a picture of expected accuracy. It is recommended that the straight-line graph be used for calibration and the curved graph for finding optimum ranges. Since the appearance of Ayres' paper in 1949, it has been widely quoted and applied. It should be read by every analyst who is seriously interested in careful photometric work.

What can the analyst do to attain the maximum accuracy within practical limitations? If the photometer available is one which provides a choice of several light paths, the analyst can choose such cells that readings on his samples will fall between 10 and 80 per cent transmittance. If the analyst is restricted to a single light path, he can dilute or concentrate—boil down or extract—samples so that the optimum photometric range can be employed. Sometimes a more sensitive method is available, one in which a more intense color can be developed with a given concentration of the constituent to be determined. If none of these choices is practical, he can often obtain better results by comparing very faint colors visually in Nessler tubes than he can by taking readings on a photoelectric instrument which are close to the 100 per cent transmittance point, owing to an inadequate light path. Finally, if for some reason the analyst must operate near the limits of the photometer scale, he should at least be aware of the dubious nature of the analytical results which will be obtained.

Presentation of Data

When photometric results obtained by different laboratories or by different procedures are to be compared, it is essential to supply enough data to permit such comparison. The exact chemical procedure, concentrations, light path, wave length, and optical densities or per cent transmittances should be given. The nature of the blank should be noted—whether it was distilled water, untreated sample, distilled water plus reagents, bleached blank, or a known concentration of the constituent. Too often information is stated in such language as, "The color was read with an ABC photometer using the XYZ filter." Usually, to decipher such cryptic information, it is necessary to search laboratory supply catalogs. There is no harm, and much good, in

reporting the instrument used, but in addition, specific information is needed. Similarly, such a statement as, "A 75 × 100 mm cuvette was used" is unnecessarily confusing. The light path was either 75 mm or it was 100 mm—it could not be both at the same time, and therefore one of the numbers is irrelevant. The reader has no way of knowing which figure represents the light path unless he owns the instrument. If the tubes, cells, or cuvettes employed do not have plane-parallel entrance and exit faces, this fact deserves mention. Data about the band pass may also be useful in interpreting discrepancies. Science is international and timeless. It is important that any statement made "here and now" will also be clear "then and there."

Verification

Although the information given previously permits a comparison of results, data from the literature should never be used as a ready-made calibration. It is essential that the analyst prepare his own calibration curve with his own instrument and reagents. It is essential that samples and standards receive the same treatment. Differences in instruments, reagents, or procedures may produce a considerable error if data taken from the literature are used as a substitute for calibration. Sandell (15, page 71) states, "Only the most sanguine user of a spectrophotometer will calculate the concentration of his colored solution from the observed extinction and the value . . . taken from the literature." Some photometer manufacturers provide precalibrated scales for certain determinations. These must be carefully checked by the analyst and discarded if they do not agree with the facts. In scientific work, facts rank above authority. Permanent glass or liquid standards should not be accepted on faith. Even if they are accurate at the time of purchase, they are calibrated for a highly specific procedure and sometimes for a particular kind of illumination, and they may fade or change color on aging or exposure to sunlight. The analyst's calibration curve should not be posted on the wall to be admired by visitors and consulted when necessary—it should be checked every time it is used. At least one blank or zero standard and one standard near the upper end of the optimum concentration range must be prepared along with every set of samples. This precaution will detect any gradual change, such as deterioration of the reagents or of the instrument, as well as any abrupt change, such as inadvertent variation in the procedure, omission of a reagent, incorrect pipet, or wrong wave-length setting. Occasionally, and at any time that any result falls under suspicion, it is well to check the entire calibration curve, by preparing approximately six standards evenly spaced over the optimum concentration range. In a few procedures the reagents spoil so rapidly, or the procedure is so sensitive to slight changes in technique—timing, temperature, and shaking—that it is imperative to prepare a set of standards with every set of samples. Some colors take a noticeable time to develop, some fade on standing, and some are bleached by exposure to sunlight.

Wave Length or Filter Selection

In general, the best wave length or filter to select is that one which gives the largest spread of readings between a standard and a blank. This selection

usually corresponds to a color which is complementary to that of the solution—a green filter for a red solution, a violet filter for a yellow solution. Sometimes a published procedure suggests a wave length, although experience has shown that this is not invariably the best one. If a spectrophotometer is available, a complete study can be made of transmittance as a function of wave length. This study may serve as a guide even though a filter photometer may later be used for the actual analysis. If only a filter photometer is available, all of the filters should be tried; perhaps a combination of two or more filters will be superior to any single filter. It is not necessary to restrict the filters to those which come with the instrument. If they will fit, filters made by other manufacturers may also be utilized.

The use of the optimum wave length or filter provides maximum sensitivity, minimum opportunity for interference from extraneous color, and closest adherence to the laws of Beer and Lambert. Occasionally it is found that the sensitivity of an analytical method is too great, so that photometric readings on some of the samples fall outside of the optimum photometric range—for example, below 10 per cent transmittance. In such an event, an obsolete practice sometimes recommended was to use a nonoptimum wave length or filter, deliberately to flatten the calibration curve in order to broaden the range. This tactic is about as sensible as removing a few spark plugs from an engine to keep down the speed of the automobile. Both tactics will accomplish their objectives, but only at the expense of efficiency. Modern photometric practice calls for the use of a smaller light path, the dilution of an aliquot of the sample, or the use of the differential transmittance method, followed by measurement at the optimum wave length. As Ayres (23) states:

> . . . the range cannot be extended over very wide concentrations, solely by the use of a filter, without decreasing the analytical accuracy. . . . For a given cell thickness and wave length of incident light, the range over which a method has its best accuracy is limited, and is in general about a seven- to tenfold-concentration range. For a given cell thickness and wave length, if a wide range is claimed for a method, the method cannot have high accuracy over this wide range, especially in the low and the high regions. Wide range is often the result of the use of a [broad band pass] filter rather than monochromatic light.

A curve of per cent transmittance as a function of wave length (Fig. 1) illustrates the various factors which determine the best choice of wave length. A hypothetical absorbing substance shows three absorption maxima or transmittance minima—that is, three wave lengths (A, B, C) at which the transmittance is lower than it is at neighboring wave lengths. If there were no other factors to be considered, one of these maxima would be about as good as another for analytical purposes. But point A is in the ultraviolet region and point C is in the infrared region. Not all photometers are capable of operating in these spectral regions. Both point A and point B represent narrow peaks. If wave length A or wave length B is approximated with a wide band-pass filter, much of the potential sensitivity is lost, because the band pass of such a filter completely brackets the narrow peak, so that the measured transmittance is an integrated average, which is consid-

erably higher than the transmittance right at the peak.

Similarly, if a spectrophotometer with an adjustable band pass is used to measure the transmittance at *A* or at *B*, the reading obtained will vary with the band pass. Points such as *D* and *E* represent steep slopes at which the transmittance varies rapidly with the wave length. Consequently, slight changes in the wave-length setting will make a large difference in the reading and, in addition, readings taken at points like *D* and *E* will show large apparent deviations from both Beer's and Lambert's laws unless very narrow band passes are used.

These deviations occur because the absorbing solution itself acts as a filter; the more concentrated the solution, or the longer the light path, the more the solution absorbs those wave lengths in the band which are more strongly absorbed. Thus, the portion of the solution closest to the light source removes a disproportionate amount of those wave lengths which are more strongly absorbed, and permits the passage of a disproportionate amount of those wave lengths which are less strongly absorbed. The portion of the solution farthest from the light source then receives the filtered light which consists, for the most part, of those wave lengths which are less strongly absorbed. The net observed result is that the per cent transmittance does not decrease with increase of concentration or of light path as much as is calculated from Beer's law or Lambert's law. For these reasons, it is advisable to avoid measurements at points on the steep sides of transmittance curves. The steeper the curve, and the broader the band pass, the greater will be the observed deviation (27, p. 78; 28, p. 1201).

Points like *F* or *G* should never be used, as they represent the worst possible choices. (Yet it is sometimes difficult to persuade even well-educated chemists not to put a blue filter in the photometer in order to measure a blue color.) Point *H* represents a fair compromise between ideality and practicality if the available instrument cannot operate at longer wave lengths. If infrared operation is possible, point *C* is the best choice; it represents a broad peak, and therefore measurements at or near *C* will have the advantage of relative freedom from variation with wave length setting or band width. In addition, natural color in water will have less effect in the infrared region than at shorter wave lengths.

Incidentally, the absorption curve between *G* and *C* is roughly similar to that of the blue pigments which are developed when solutions of silica, arsenic, or phosphate are treated with ammonium molybdate and reducing agent (13, pp. 44, 46, 79). The broad plateau of maximum sensitivity occurs in the near infrared, but this region is accessible only with the more expensive photometers. The owner of a less versatile instrument is obliged to operate at some point like *H*, and must therefore be content with a lower sensitivity. In several determinations, *Standard Methods* (13) specifies nonoptimum wave lengths, presumably because the data were originally obtained with instruments of limited scope. Turning to the other end of the spectrum, many yellow solutions show their maximum absorption in the near ultraviolet region between 380 and 400 mμ or even at lower wave lengths, and a lesser degree of absorption in the visible violet region. Examples are solutions of chromates, solutions of nitrites, and the Nessler ammonia color.

The effect of interfering color upon the choice of wave length or filter is illustrated in Fig. 2, which represents two hypothetical absorbing substances. The solid line presents the transmittance of the developed color that is to be determined. The broken curve presents the transmittance of some interfering substance, known or suspected to be present, which is difficult or impossible to remove by pretreatment, and which cannot be compensated for by one of the techniques yet to be described. The absorbing substance that

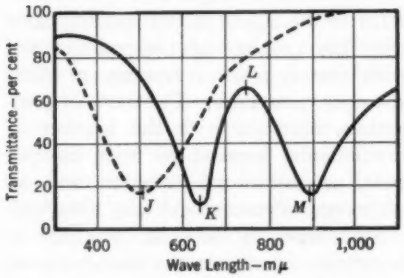

Fig. 2. Transmittance as a Function of Wave Length

The effect of interfering color upon the choice of wave length or filter is illustrated by two hypothetical absorbing substances. The letters refer to points on the curve.

is being determined shows two absorption maxima, represented by points *K* and *M*. Point *K* provides greater sensitivity than point *M*, but unfortunately, the interfering substance absorbs more strongly in the vicinity of point *K* than it does in the vicinity of point *M*. In practice, point *M* would probably be the better choice.

Minimizing Interferences

An interfering substance may either increase or decrease the readings. It may produce a color of its own, or it may combine either with the sought constituent or with the color-producing reagent in such a way as to hinder full color development. Two or more interfering substances, when present simultaneously, may produce a resultant interference which could not have been predicted from their separate interfering effects.

The best way to minimize interference is to remove whatever substance is responsible. If this cannot be done by actual separation—precipitation or extraction—it may be possible (by oxidation, reduction, pH control, or use of complexing agents) to render the interfering substance relatively innocuous. Nowadays, procedures are being devised in which the desired color is extracted from the aqueous solution in which it has been developed, into an immiscible organic solvent. Such a stratagem may, in addition to removing an interfering color or turbidity, simultaneously increase the sensitivity by concentrating the colored (absorbing) material in a smaller liquid volume. Molybdenum blue may be extracted into ether; the reaction product of phenols with Gibbs' reagent may be extracted into butanol; the reaction product of phenols with 4-aminoantipyrine may be extracted into chloroform; and the reaction product of copper with sodium diethyl dithiocarbamate may be extracted into carbon tetrachloride. In the Gibbs' reaction, extraction into butanol enhances the intensity of the color and reduces the annoying discrepancy between the color that is produced by phenol and that produced by cresols. The search for suitable organic solvents has received stimulation because of increasing interest in detection of industrial wastes, insecticides, and radioisotopes in very low concentration.

If color or turbidity is present initially in the sample, and if it can be proved that the process of color development does not affect the initial color or turbidity, it is possible to measure the optical density of the sample both before and after developing the color. The difference in density will then represent the density due to only the developed color. Dilution by added reagents, and any color—optical density—of the reagents themselves, must be taken into account.

A method sometimes available for the compensation of interferences is that of the bleached blank. If it is possible to destroy the desired colored substance without affecting the interfering color or turbidity, then the optical density of the solution may be measured both before and after destroying the desired color. The difference in optical density here again represents the optical density due to the desired color. The periodate procedure for manganese—for example—may be applied in the presence of interfering color or turbidity by determining the optical density both before and after adding a drop of sodium nitrite solution, which decolorizes permanganate.

A more cumbersome method which is sometimes applied when others fail is that of algebraic correction. If the absorptions of two or more simultaneously present substances overlap (as at *J* or *K* in Fig. 2), and if nearly monochromatic light is used, each substance may be determined in the presence of the others. A calibration curve for the separate substances is required. The results are reached by solution of simultaneous equations (15, p. 70). Weissler (29) applied this technique to determine titanium, vanadium, and molybdenum in the same solution, at the same time, and with the same color-developing reagent. Sandell (15, p. 150) suggests that it is possible to determine iron and aluminum simultaneously with hematoxylin. Kitson (30) was able to determine cobalt, copper, and iron simultaneously. The algebraic method has reached its highest development in the infrared analyses used in the petroleum industry. Unfortunately, errors tend to become cumulative. Recently Hiskey (31) has shown that ten times the ordinary accuracy can be obtained by the combination of the differential and algebraic techniques. As might be expected, the error of the algebraic method increases with the number of components and with the degree of overlap of their absorption maxima. The work of computing increases with the number of components, because for each component, an additional equation and an additional measurement are required.

Sometimes it may be practical to determine separately the concentration of an interfering substance, and to add deliberately the same concentration to the calibration standards. This compensates for the interference very well, but involves much extra work.

Sometimes the interference is of such a nature that it can be swamped by adding to every sample and to every standard such an overwhelming quantity of the interfering substance that the initially-present quantities are no longer significant. For this technique to be useful, the interference effect must approach or reach a limiting value as the amount of interfering substance increases. In the determination of fluoride (13, p. 76) so much sulfate is added to both samples and standards that the initial concentrations of the water samples no longer matter greatly. If this precaution were omitted, each sample would have to be corrected for

its sulfate content. In the determination of magnesium with titan yellow (13, p. 61), so much calcium is added that the initial calcium contents of the samples are negligible by comparison.

Differential Photometry

It is possible to increase the accuracy of photometric measurements by a factor of from five to twenty times the ordinary accuracy by using a recently developed technique which has been described by Hiskey (25, 28, 32, 33) and Bastian (34–36). In differential photometry, or the transmittance ratio technique, the reference standard which is used to set the instrument to 100 per cent transmittance is not a zero blank, as is ordinarily used, but is purposely chosen to contain nearly as great a concentration of the sought constituent as is expected in the samples. Essentially, the photometer reading provides a small correction value which is added to the known concentration value of the reference solution. The simplest mechanical analogy is the use of a vernier in reading a scale. The statements made earlier in this paper about the optimum portion of a photometer scale do not hold for differential photometry; in this refined technique, the closer the sample is to the standard—that is, to 100.0 per cent transmittance—the better is the accuracy. Most of the experimental work reported has involved rather high concentrations of absorbing substances because the substances chosen did not possess intense colors, but the important consideration is not the high concentration but the high optical density of the reference solution. Naturally, if the color is not sufficiently intense, either a high concentration or a long light path will be necessary.

Not every photometer is suitable for differential photometry (32), but only those which are, or can be made, extremely sensitive. Under the proper circumstances, the results obtained by differential photometry can equal or excel those obtained by gravimetric or volumetric analyses.

Spectrophotometric Identification

All of the previous discussion has been based upon the premise that the problem to be solved is the quantitative photometric determination of a constituent which is, or may be, present in a water sample. In addition to this important function, the spectrophotometer also sometimes permits the identification of unknown substances, because complete transmission curves—absorption spectra—are characteristic. The author was able to identify a pigment which had accumulated in the shallows along the shoreline of Silver Lake Reservoir, and which had engendered considerable curiosity and some concern, as phycocyan, one of the pigments of the blue-green algae, by comparing the characteristic shape of the absorption spectrum as found in the laboratory with that reported in the literature.

For identification purposes, it is most convenient to plot the logarithm of the optical density as a function of wave length, because this mode of plotting data eliminates any differences in curve shape with changes in concentration. As the concentration is altered, the entire curve is elevated or depressed, but remains always parallel to itself.

The spectrophotometer is also useful for studies on new color systems and for studies on color filters for filter photometers.

Summary

Photometric techniques are widely used in water analysis because of their sensitivity, rapidity, and convenience. Both visual and photoelectric methods can be used; each has its advantages. An elementary knowledge of light absorption principles will enable the analyst to obtain the best possible accuracy with the equipment at his disposal.

The analyst who becomes interested in a more thorough investigation of photometric methods will find a wealth of literature to read and study. He will find that his appreciation and utilization of the possibilities of theory applied to practical problems in the laboratory will increase in proportion to his knowledge and experience.

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References

1. MELLON, M. G. Light Absorption Spectrometry. Anal. Chem., **21**:3 (1949).
2. *Ibid.* **22**:2 (1950).
3. *Ibid.* **23**:2 (1951).
4. *Ibid.* **24**:2 (1952).
5. MELLON, M. G. *Colorimetry for Chemists.* G. F. Smith Chemical Co., Columbus, Ohio (1945).
6. ———. Light Absorption Spectrometry. Ind. Eng. Chem.—Anal. Ed., **17**:81 (1945).
7. GIBSON, K. S. Spectrophotometry. Natl. Bureau of Standards Circular 484. Supt. of Documents, U.S. Government Printing Office, Washington, D.C. (1949).
8. KOLTHOFF, I. M., & SANDELL, E. B. *Textbook of Quantitative Inorganic Analysis.* Macmillan Co., New York (1945), Chap. 41.
9. WEST, W. Chapters 21 and 22 in WEISSBERGER, A. *Physical Methods of Organic Chemistry.* Vol. 1, Part 2. Interscience Publishers, Inc., New York (2nd ed., 1949).
10. VREDENBURG, R. M. *Guide to Photometric Analysis.* Fisher Scientific Co., Pittsburgh (1950).
11. GIBB, T. R. P. *Optical Methods of Chemical Analysis.* McGraw-Hill Book Co., New York (1942). Chap. 2 and 3.
12. *Symposium on Analytical Colorimetry and Photometry.* Am. Soc. Testing Materials, Philadelphia, Pa. (1944).
13. *Standard Methods for the Examination of Water and Sewage.* Am. Pub. Health Assn. & Am. Water Works Assn., New York (9th ed., 1946).
14. MELLON, M. G. (ed.). *Analytical Absorption Spectroscopy.* John Wiley & Sons, New York (1950).
15. SANDELL, E. B. *Colorimetric Determination of Traces of Metals.* Interscience Publishers, Inc., New York (2nd ed., 1950).
16. SNELL, F. D., & SNELL, C. T. *Colorimetric Methods of Analysis.* Vol. 1. D. Van Nostrand Co., New York (3rd ed., 1948).
17. Colorimetry—A Panel Discussion. AS TM Bul. No. **142**:38 (Dec. 1950).
18. COOPER, S. S. Color Filters in Filter Photometry. Ind. Eng. Chem.—Anal. Ed., **19**:254 (1947).
19. HARRISON, G. R.; LORD, R. C.; & LOOFBOUROW, J. R. *Practical Spectroscopy.* Prentice-Hall Inc., New York (1948). Chap. 14.

20. FRIEDEL, R. A., & ORCHIN, M. *Ultraviolet Spectra of Aromatic Compounds.* John Wiley & Sons, New York (1951). Chap. 2 and 6.
21. LOTHIAN, G. F. *Absorption Spectrophotometry.* Hilger & Watts, London (1949).
22. STRONG, F. C. Theoretical Basis of the Bouguer-Beer Law of Radiation Absorption. Anal. Chem., **24**:338 (1952).
23. AYRES, G. H. Evaluation of Accuracy in Photometric Analysis. Anal. Chem., **21**:652 (1949).
24. HAMILTON, R. H. Photoelectric Photometry, An Analysis of Errors at High and at Low Absorption. Ind. Eng. Chem.—Anal. Ed., **16**:123 (1944).
25. HISKEY, C. F. Principles of Precision Colorimetry. Anal. Chem., **21**:1440 (1949).
26. RINGBOM, A. On the Accuracy of Colorimetric Methods of Analysis. Z. Anal. Chem., **115**:332 (1939).
27. ASHLEY, S. E. Q. Spectrophotometric Methods in Modern Analytical Chemistry. Ind. Eng. Chem.—Anal. Ed., **11**:72 (1939).
28. HISKEY, C. F., & YOUNG, I. G. Principles of Precision Colorimetry. Absorption Law Deviations in Measurements of Relative Transmittance. Anal. Chem., **23**:1196 (1951).
29. WEISSLER, A. Simultaneous Spectrophotometric Determination of Titanium, Vanadium, and Molybdenum. Ind. Eng. Chem.—Anal. Ed., **17**:695 (1945).
30. KITSON, R. E. Simultaneous Spectrophotometric Determination of Cobalt, Copper, and Iron. Anal. Chem., **22**: 664 (1950).
31. HISKEY, C. F., & FIRESTONE, D. Precision Colorimetry. General Method of Improving Precision in Multicomponent Spectrophotometry and Some Practical Consequences Thereof. Anal. Chem., **24**:342 (1952).
32. HISKEY, C. F.; RABINOWITZ, J.; & YOUNG, I. G. Principles of Precision Colorimetry. Measuring Maximum Precision Attainable With Commercial Instruments. Anal. Chem., **22**:1464 (1950).
33. YOUNG, I. G., & HISKEY, C. F. Precision Colorimetry. Application to Determination of Manganese. Anal. Chem., **23**:506 (1951).
34. BASTIAN, R. Determination of High Percentages of Copper With a Beckman Spectrophotometer. Anal. Chem., **21**:972 (1949).
35. BASTIAN, R.; WEBERLING, R.; & PALILLA, F. Differential Analysis With a Beckman Spectrophotometer. Anal. Chem., **22**:160 (1950).
36. BASTIAN, R. Differential Spectrophotometric Determination of High Percentages of Nickel. Anal. Chem., **23**: 580 (1951).
37. GRIDGEMAN, N. T. Reliability of Photoelectric Photometry. Anal. Chem., **24**:445 (1952).
38. BERGER, A., & VERBESTEL, J. Colorimetry and Absorptiometry. Bul. Centre Belge Etude et Document Eaux (Liège), **8**:503 (1950).

Trained Operators—A Municipal Responsibility

By William T. Ingram

A paper presented on April 17, 1952, at the New York Section Meeting, Syracuse, N.Y., by William T. Ingram, Assoc. Prof. of Public Health Eng., New York University, New York, N.Y.

NEW York State has public water systems serving more than 90 per cent of its fourteen million population. According to data prepared by the State Dept. of Health (1), these supplies serve communities ranging in size from the smallest hamlet to the largest metropolitan area in the country. Although the great majority of water utilities are small (median population served, 1,000), the fact that 900 systems serve almost 1,400 communities indicates that the bulk of the population is served by comparatively few utilities. As of 1948, ground water supplies predominated in number—479—but served only 13.8 per cent of the total population served. The number of communities served by surface supplies—637—and the number served by ground supplies—664—were nearly equal.

In 1948, 512 supplies (58 per cent) were municipally owned. The methods of treatment varied—291 plants had some form of chlorination as the sole treatment, 102 had mechanical filtration plus chlorination, and 128 had slow sand filtration with chlorination. All forms of treatment brought the total of treated supplies to 447. Thus, approximately one half of the public supplies of the state are treated.

These facts and figures mean simply that the job of supplying water to most of the population of New York State is in the hands of many operators and supervisory personnel who have a responsibility to operate the system from source to customer service connection so that a safe, potable water is available for use.

Waterborne Outbreaks

This responsibility is not one to be taken lightly, and the record of waterborne outbreaks in New York State for the years 1937–49 shows quite clearly that it has not been. The record also shows that eternal vigilance by management and operation by trained personnel are necessary. Outbreaks still occur in sufficient numbers to be impressive, for the desirable record is and should be no outbreaks traceable to public water system service.

Wolman and Gorman (2, 3) have made several reports on waterborne outbreaks and other studies were made by Eliassen and Cummings (4). The author has examined reported outbreaks occurring in New York from 1937 to 1949. An examination of the thirteen-year record of waterborne outbreaks in which public water systems of New York State have been involved is enlightening (Tables 1 and 2). In six outbreaks which resulted in 3,650 cases of enteric disease, faulty chlorination or other treatment practice was the cause. More than 19,000 peo-

TABLE 1

Waterborne Outbreaks Reported in New York State 1937–49

Location of Outbreak	Year	Est. Resident Pop. Served	Est. Pop. Exposed	No. Cases Illness*	Cause of Outbreak†
Ravena	1938	2,500	2,500	84	C
Buffalo Airport	1938	Unknown	1,030	90	F
Forestville area	1939	450	450	60	B
Seneca Falls area	1940	6,450	6,000	390	J
Canastota area	1940	4,150	4,200	448	D
Chenango Bridge area	1940	750	400	109	J
Mayville area	1940	1,350	1,350	190	J
Rochester	1940	324,980	436,300	35,006	E
Industrial Plant, Berlin	1941	480	20	20	H
Sidney area	1942	4,400	6,700	2,329	B
Hadley, Luzerne	1942	1,000	1,000	200	G
Newcomb, Essex Co.	1942	Unknown	Unknown	50	J
Industrial Plant, Port Washington	1942	1,200	Unknown	325	F
Laurel Hill‡	1942	7,625,000	3,000	225	E
Cairo area	1943	360	500	215	B
Greenwich area	1945	2,270	3,000	23	I
Industrial Plant, Irvington	1945	3,220	80	14	H
Geneva	1945	27,500	27,500	4,000	I
Ellenville	1945	4,000	4,000	800	B
Westport area	1946	650	650	150	A
Westport area	1946	650	650	100	A
Deansboro area	1946	300	210	67	A
Tannersville	1946	5,000	5,000	162	B
West Hempstead	1946	4,000	Unknown	67	F
Resort, Northhampton Twp.	1947	1,550	1,150	75	J
Resort Hotel, Kinderhook	1947	740	25	21	I
Hotel, Monticello	1948	12,000	40	15	J
Apt. House, New York‡	1949	7,800,000	380	31	J
School, New Paltz	1949	1,490	160	54	D
Totals (29)		15,836,440 (2 Unknown)	506,295 (3 Unknown)	45,320	

* The illness was gastroenteritis in every town except Ravena and New York in which it was bacillary dysentery, and Rochester, in which there were six cases of typhoid and 35,000 cases of gastroenteritis.

† Key to symbols:
A—Contamination of brook or stream by pollution on watershed.
B—Inadequate chlorination. Chlorination only treatment used.
C—Interruption of chlorination. Chlorination only treatment used.
D—Pollution of water mains.
E—Cross-connection with polluted water supply.
F—Break in mains permitting sewage or river water to enter.
G—Defect in building plumbing, back siphonage.
H—Use of polluted private supply because of objectionable taste or quality of public supply.
I—Cause of outbreak undetermined.
J—Data insufficient for classification.

‡ Served by New York City supply.

ple were exposed to this hazard. Eight outbreaks comprising 36,415 cases of enteric disease were traced to pollution of water lines through cross-connections, building plumbing defects, line breaks, and leakage. Approximately 447,000 people were subjected to these known hazards.

In 29 outbreaks, 28 systems were involved. One community that did not treat its surface water supply sustained two outbreaks in the same year because

TABLE 2

Classification of Waterborne Outbreaks by Cause

Outbreak	No. and Cause of Outbreak*										
	A	B	C	D	E	F	G	H	I	J	Totals
No. of Outbreaks	2	5	1	2	2	3	1	2	3	8	29
No. Cases Typhoid					6						6
No. Cases Gastroenteritis	317	3,566		502	35,225	482	200	20	4,044	843	45,199
No. Cases Bacillary Dysentery			84							31	115
Total No. Cases Illness	317	3,566	84	502	35,231	482	200	20	4,044	874	45,320
Avg. Cases per Outbreak	158	713	84	251	17,616	161	200	10	1,348	109	1,563
No. Persons Exposed	1,510	16,650	2,500	4,360	439,300	1,030+	1,000	20	30,525	9,400+	506,295+

* See Table 1, p. 649, for key to symbols.

of contamination of water by watershed pollution.

The outbreaks were limited for the most part to gastroenteritis, mainly because of early detection of defect, prompt remedial measures, and alertness on the part of both health and water works personnel. It is creditable that, during this thirteen-year period, only 6 cases of typhoid fever and 115 cases of bacillary dysentery were attributable to public system waterborne outbreaks.

Two questions are relevant at this point. Why have so few major outbreaks occurred in New York State? Only those outbreaks at Rochester, Geneva, and Sidney involved more than 1,000 persons, although 1,563 was the average number of cases per outbreak for the period. How can there be an assurance that such outbreaks will be minimized—reduced to even less than the record of these past years? One answer to these questions is especially significant: An adequate number of personnel suitably trained in water works practice can operate and maintain a water system so that it is subject only to the hazards of poor design and inadequate provision for protection of source, transmission, treatment, or distribution, over which operating personnel may have little control, but which superior operation and maintenance have been known to reduce.

The State Health Council has established rules for qualification of operators, and has provided, in cooperation with the Municipal Training Institute of New York State, a scheme of water works operator training that has been successful in providing, to those municipalities that wish to take advantage of it, a continuing supply of operators trained to share a responsibility for furnishing water of good quality to the public.

State Rules

Chapter XI, Section E, of the Sanitary Code (5) pertains to operators of public water treatment and purification plants. Regulation 36, enacted in 1937 and amended in 1940 and 1946, made the qualifications mandatory with the usual exceptions protecting those employed at the time the rule was adopted.

Grade I, II, and III operator classifications and the water plant or purification process at which the different grades of operators are required are defined. Qualifications for each grade are established.

Although each of the qualifications has alternate and substitute provisions, the primary requisites are:

Grade I. University degree in public health, sanitary, chemical, or civil engineering, plus one year of water purification plant experience, or completion of a course of instruction in water purification or instruction approved by the public health council for this grade, plus five years of experience in water purification.

Grade II. Graduation from high school and completion of a course of instruction in water purification or treatment approved by the public health council for this grade, plus one year of experience, or completion of the course plus three years of satisfactory experience.

Grade III. One year of satisfactory experience in a water purification or treatment plant, or completion of a course of instruction in water purification or treatment approved by the public health council, plus three months' satisfactory experience.

Training Courses

The State Health Dept. Bureau of Environmental Sanitation has conducted a training program since the establishment of the rules governing operator qualifications. Short schools for Grades II and III have been developed with the assistance of and in cooperation with public and quasi-public groups, such as the New York State Conference of Mayors, the Assn. of Towns of the State of New York, the Bureau of Public Service Training of the New York State Dept. of Education, and the New York Section of AWWA. University facilities have been utilized. Grade III courses have been given at both university locations and at numerous meeting places in the state. No Grade I short school has been conducted as yet. At a conference on training in Albany in 1951, the possibility of having such schools was discussed at length. Grade II operators may hope, then, to have available some opportunity for advanced training.

Noteworthy in the record of progress is the forward position taken by the Bureau of Environmental Sanitation. Staff time has been given freely to the conduct of training courses. The entire staff of the Bureau has contributed to the success of the training program.

In 1950 a special committee was appointed to study the needs and propose a plan for training sanitation personnel in New York State (6). One of the major recommendations of this committee proposed the establishment of a training section in the Bureau of Environmental Sanitation. The recommendation has been followed. As a result of the establishment of the training section, water works training is on a more secure footing, and all categories of sanitation training are being soundly developed. The New York State Health Dept. is indeed fulfilling its responsibility as coordinator of training within the state.

Water Works Courses

The philosophy, objectives, and course content of water works schools in the U.S. have been reviewed as recently as 1948 (7). The pattern of training in New York State, by national standards, is sound and progressive, and shows improvement.

Grade III courses are conducted on a three-day basis at locations convenient to operators. Much of the course content is devoted to discussion of principles and practices of chlorination, demonstration of the testing tech-

niques used for detecting the presence of chlorine, and the maintenance and operation of chlorination equipment. The basic school staff is comprised of personnel from the Bureau of Environmental Sanitation and Div. of Laboratories. Water works operators and industrial specialists augment the schedule.

Grade II courses are conducted on an informal rotation basis at Niagara University, Cornell University, Rensselaer Polytechnic Institute, and New York University. Each university has prepared its curriculum and has submitted it to the State Health Dept. for approval. Unavoidable differences in course hours and scheduling make the training programs slightly variable, but the general characteristics are comparable. A comparison prepared for committee study brought out three features:

1. Course hours: at New York University—71, at Cornell and Rensselaer Polytechnic Institute—80, and at Niagara—90.

2. Class hours: at New York University—50, at Cornell and Rensselaer —53, and at Niagara—64.

3. Laboratory hours: at New York University—21, at Cornell and Rensselaer—27, and at Niagara—26.

Representatives of the universities met with state health department officials in November 1951, and resolved the course content, subject to future modification, into the subjects and approximate proportions of time given in Table 3.

It was generally agreed that the approximate distribution of time between classroom and laboratory should be 65 to 35 per cent, respectively. Text reading assignments and daily problems are an out-of-class activity that adds approximately three hours a day to the total time spent.

The course, as outlined in Table 3, presumes that trainees are sufficiently grounded in arithmetic to require no major time for exercises in addition, subtraction, multiplication, and division. Those who have presented the courses have found that the arithmetic exercises take up valuable course time and lessen the progress that can be made by the more able trainees. Prospective applicants for Grade II courses must assume a personal responsibility for obtaining some proficiency in arithmetic before attending classes.

TABLE 3

Subjects Given in Grade II Courses

Subjects	Total Time *per cent*
1. Public health factors including sanitary code provisions, public relations, emergency operation, etc.	6
2. Bacteriology	20
3. Biology	7
4. Chemistry	7
5. Sources of supply	3
6. Water treatment plants and their operation	27
7. Pumps and equipment	6
8. Review, discussions, and examinations	20
9. General subjects including records, record keeping, laboratory reports, and problems.	4

The course is intended to acquaint the trainee with all of the major treatment processes, but emphasis is given flocculation, sedimentation, filtration, and chlorination, the fundamentals in modern water purification and treatment practice. The trainee is introduced to bacteriology, biology, and chemistry as they apply to water purification. The author has found, from discussions with operators who have

taken the course, that it gives them a sufficient background to explore current water treatment literature and to continue learning about the intricacies of water works with comparative ease and assurance. Some operators have found that additional benefits of the course are apparent as much as six months to a year later as plant experiences are associated with information obtained at school.

On-the-job Training

In addition to the somewhat formalized training discussed, a continuous training program should be available at every plant. On-the-job training has peculiar values both for those preparing for Grades II and III short schools and for those who have completed the courses. On-the-job training is available from either state engineers working out of regional and district offices, county and city health department sanitary engineers, public works staff, or fellow operators.

On-the-job training may be casual and unrecognized, as the visitors to the plant discuss operating problems and make suggestions for improvements. It may be a one-hour session between the superintendent and his operators at regular periods, or it may be a prearranged afternoon or evening session of several neighboring operators at one plant for the purpose of looking at the treatment process and discussing the successes or failures in operation of both process and equipment.

These informational exchanges are more than a break in the humdrum routine. They demonstrate the occurrence of problems common to operators regardless of plant. They whet curiosity and satisfy questions arising out of differences in practice. They stimulate the alert operator to a critical review of his own knowledge of practices. They emphasize that all-important fact that water works operation is a responsible job requiring more than manual dexterity.

Although this paper is limited to nonacademic water works operator training, it is desirable to call attention to the state rules concerning Grade I qualifications. Short courses—no matter how good—cannot serve as a replacement for the more extensive education in fundamentals of chemistry, microbiology, and engineering essential to an understanding of the complex processes and equipment found at major works. The more progressive operator, by education acquired through experience, special courses, and academic study in basic sciences, can conceivably satisfy the requirements for Grade I, but qualification is far simpler and less time consuming when academic education at the college level is part of that experience.

Summary

The municipal water works management is under an obligation to furnish an adequate supply of potable water to the public it serves. Not only must the physical works be capable of providing the water, but the system must be maintained and operated so that it introduces no hazards. Management has not fully met its responsibility if system operators are unqualified. It follows, then, that management should employ qualified operators at the outset or should make it possible for the operators chosen to become qualified. It is fortunate for the public of New York State that water works officials

of its several hundred systems have recognized the wisdom of these concepts. The State Health Dept. and Municipal Training Institute have cooperated to make available a comprehensive continuing program of training, in support of on-the-job training for Grade II and III operators. Although many municipalities have supported the training schools and, in turn, have profited by the experience and greater knowledge of trained operators, some have not yet done so. The latter group may well review their position. The goals for water works protection in New York State should include support of the training schools.

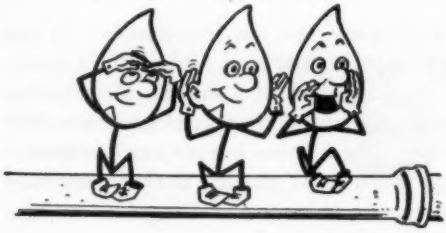
Every operator should be qualified for the position he holds. It is a municipal responsibility to be certain that he is. There can be little excuse for failure, as adequate opportunities for qualification training are available.

References

1. Public Water Supply Data for New York State. New York State Health Dept., Albany, N.Y. Bul. 19 (1948).
2. WOLMAN, A., & GORMAN, A. E. *The Significance of Waterborne Typhoid Fever Outbreaks, 1920–1930.* The Williams & Wilkins Co., Baltimore, Md. (1931).
3. Gorman, A. E., & WOLMAN, A. Waterborne Outbreaks in the United States and Canada and Their Significance. Jour. AWWA, **31**:2 (Feb. 1939).
4. ELIASSEN, ROLF, & CUMMINGS, ROBERT H. Analysis of Waterborne Outbreaks, 1938–45. Jour. AWWA, **40**: 509 (May 1948).
5. The Sanitary Code Established by the Public Health Council of the State of New York. New York State Health Dept., Albany, N.Y. (1950).
6. O'BRIEN, J. F., & AMOS, F. B. New York State Training Program for Sanitation Personnel. Modern San., **4**:4:17 (Apr. 1952).
7. INGRAM, W. T. ET AL. Scope and Value of Water Works Schools. Jour. AWWA, **40**:1005 (Oct. 1948).

NPA Reclassification Suspended; Copper, Aluminum Eased

The pending reclassification of water plants from the commercial to the industrial construction category, as announced in the June 1952 JOURNAL (Vol. 44, p. 502), is being suspended by NPA pending a determination of the result of the steel strike. An easing of supplies of copper and aluminum, however, has increased the self-certification limits of these metals to 750 lb and 1,000 lb per quarter, respectively. The previous limit had been 200 lb for copper and copper-base alloys, and aluminum had not been subject to self-authorization. The new limits for these metals became effective June 18, 1952.



Percolation and Runoff

State is what Secretary Harry E. Jordan is now almost of. What made him that way was representing AWWA at the Second International Water Supply Congress held in Paris, June 9 to 13. It wasn't what he and 800 other water works men from 20 different countries did during the daylight hours that particularly interested us, but since that's the best we've been able to get out of him, we'll have to postpone our "Plastered in Paris" caption till next month and let him report his foreign ministrations as they really happened:

The technical sessions were held at the "Maison de la Chimie," with excursions to Versailles and to Fontainbleau. The meetings were conducted in French and English, with two and three sessions held in parallel—but the complexity never reached the point of disrupting the discussions. Reports were scheduled and discussed on the following subjects: standards for expressing the results of physical, chemical, and bacteriological analysis; artificial replenishment of ground water; treatment of water before filtration; softening; survey of the supply and delivery systems including flow and pressure control and leak detection; protection of networks against corrosion; the presence of algae in waters; experimental verification of the different formulas used for pipeline flow; calculation of mesh networks; and protection of surface water against external pollution, both legal and technical. Final reports were delivered on such subjects, first discussed in 1949, as: technical nomenclature; legislative measures for the development of rural water supplies; and rapid filters.

The report on algae and their control was made by D. H. Matheson, engineer in charge of purification at the Hamilton, Ont., filtration plant, and was a great credit to its author.

Fluoridation of drinking water was not a scheduled item in the sessions but much interest was manifested in it, and Secretary Jordan had several informal conferences with persons who wished to be informed of the advances in this field in the U.S.

(Continued on page 2)

(*Continued from page 1*)

Brief visits were also made to England and the Netherlands. It was interesting to see some of James Simpson's slow sand filters still in operation in London. H. F. Cronin, chief engineer of London's Metropolitan Water Board, disclosed that London, like many American cities, is suffering growing pains in water demand. The likeness is even more strikingly shown by the fact that the Ministry of Public Works has not yet authorized the expansion of the storage requirements which the chief engineer strongly recommends.

In the Netherlands, the ground water recharge and control works of Leyden were studied in company with Pieter C. Lindenbergh, the engineer of the property (*see* September 1951 JOURNAL). It was startling to see the "west-wall" works of the Nazis which they erected right across the well field, as a defense against the "D" day landing. While the German officers recognized the essentiality of Dr. Lindenbergh's task and allowed him to go about his work, "trigger-happy" soldiers frequently took "pot shots" at him. Luckily he escaped injury.

A most interesting conference was had with Dr. L. E. Carriere, the chief of the "Institute for Testing Water Works Materials." This incorporated agency, separate from the water works association, is owned by the water works utilities of the Netherlands. The agency not only draws up specifications for such water works materials as pipe and meters, but tests the finished products (on a very moderate fee basis) to see that the material sold conforms to the standards. AWWA can give some thought to this operation, and a more complete record of the procedure will appear in a later issue of the JOURNAL.

Your Secretary, accompanied by his wife and daughter, spent an intensive three weeks of travel beginning at the Montreal meeting of the Canadian Section, then going on to London, Amsterdam and Paris. It wasn't until their return to the U.S., marked by a strike of the Long Island Railroad engineers, that they really had travel trouble.

Light water can be about as big a problem as heavy water—at least when it's for fluorescent lights. If ordinary tap water is used in the manufacture of phosphor coatings or glass, or in the washing of the lamps, the dissolved solids contained have the effect of cutting light output in the finished lamp. To provide practically perfect water for these purposes, General Electric recently installed in its Chemical Products Works a custom-built ion exchanger that will produce 20,000 gpd with less than 1 ppm chemical impurities—considerably better than USP-grade distilled water. That's purity alright, but we, who enjoy body and flavor as well, will take our drink on, if not out of a, tap—also light!

(*Continued on page 4*)

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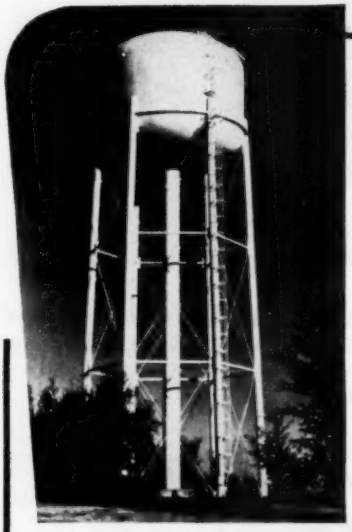
(*Continued from page 2*)

A safety first was presented to the Detroit Board of Water Commissioners last April by the National Safety Council—its "Award of Merit" for outstanding employee safety performance during 1951. Credit for the accomplishment goes first to General Manager Larry Lenhardt, under whose direction a full-time safety program was instituted as long ago as 1942, and next to Safety Officer Ken Day, who is in responsible charge of the program's operation. And, incidentally, AWWA deserves credit too, for picking a winner in its recent appointment of Day to the chairmanship of a new Association task group on safety. Not only is safety becoming a first concern of the water works field today, but, by the appointment, to Day.

The ice age is really here! Frozen peas, frozen chicken, frozen potatoes (only temporarily, frozen biscuits), frozen coffee, frozen strawberries, and now, logically enough, frozen sewage. British studies, reported in the March issue of *Industrial and Engineering Chemistry,* indicate that freezing of primary, digested, or activated sludge not only hastens settling but also increases filtration rates considerably. It won't be long now till hell freezes over!

(*Continued on page 6*)



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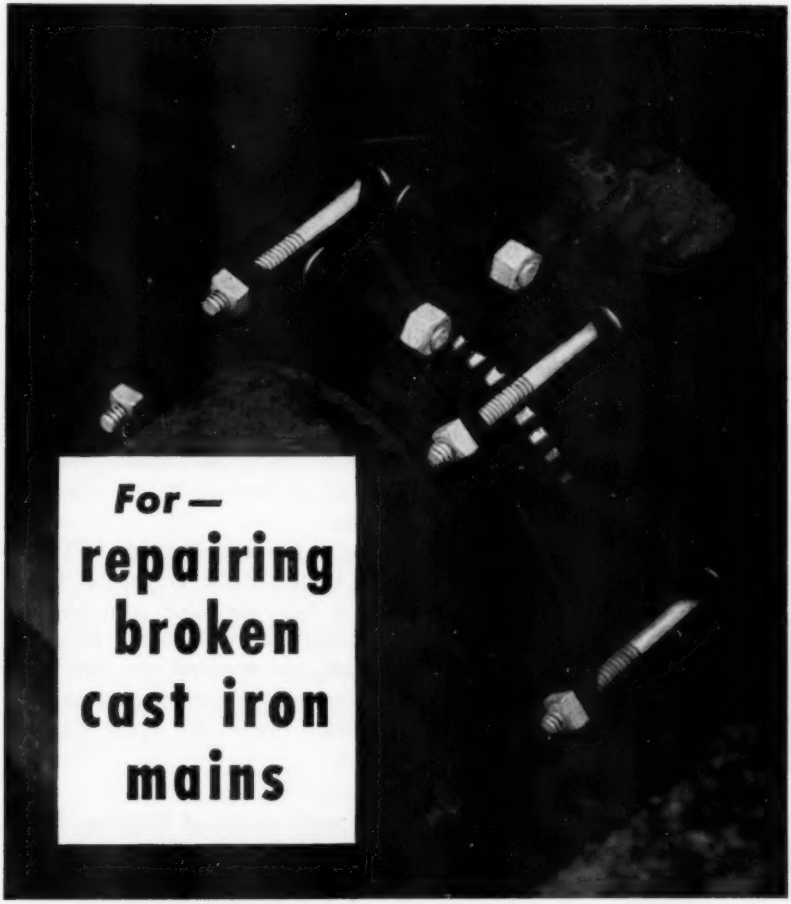

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(*Continued from page 4*)

Joseph W. Mountin, assistant surgeon general and chief of the Bureau of State Services of the Public Health Service, died on April 26 at the age of 61. Long known as an authority in such environmental health fields as sanitation, water pollution control, and industrial hygiene, his connection with the Public Health Service dates back to World War I.

Jesse J. Woltmann, Bloomington, Ill., consultant, died on May 2 at the age of 63. At one time acting chief of the Illinois State Water Survey, he was an AWWA Director from 1945 to 1948 and at one time was chairman of the Illinois Section. In addition, he was an Honorary Member and past president of the Illinois Society of Professional Engineers.

Earle P. Johnson, district manager for Wallace & Tiernan Co. in the Pittsburgh area, died on May 11, at the age of 49, after an extended illness.

A graduate of Carnegie Institute in Pittsburgh in 1925, he joined the Wallace & Tiernan organization there the same year, becoming district manager in 1930. Only six days before his death, he received the AWWA Pennsylvania Section's Fuller Award in absentia in the award ceremonies at the Kansas City Conference.

John J. Kapp Jr., superintendent of public works at Haledon, N.J., died on May 14 after a long illness. He was 73. An immigrant from Germany in 1896, he went to work for the community in 1910 as district clerk and became public works superintendent in 1923.

Clyde C. Kennedy, consulting engineer of San Francisco, died on April 26, at the age of 71. The consulting firm which he organized 35 years ago had planned numerous water supply and sewage projects in the California and Arizona area.

The microfilm edition of the 1951 JOURNAL is now available from University Microfilms, Ann Arbor, Mich., and may be purchased at a cost of $6.35 by regular JOURNAL subscribers and AWWA Members. This brings to a total of three the number of annual volumes that are available in microfilm form. The cost of the 1949 volume is $6.25; that of 1950 is $8.00.

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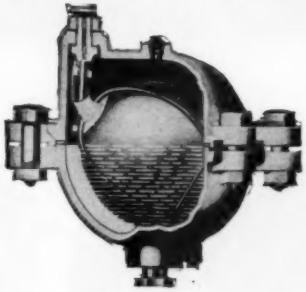

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WHEN air lodges at high spots in pipe lines, it reduces the effective area of the pipe, creates a friction head, lowers pumping capacity, and may result in serious water hammer!

Simplex Air Release Valves bring you a sure, efficient cure for these difficulties . . . venting air *automatically before it can cause damage.*

The Simplex Air Valve is easily-installed . . . positive in action . . . ample in capacity. Standard valves for pressures up to 250 p.s.i. . . . special valves for pressures up to 800 p.s.i. Thousands have been in successful use for over 30 years.

Write for free bulletin to Simplex Valve & Meter Co., Dept. 7, 6784 Upland St., Philadelphia 42, Pa.

IT'S SIMPLEX
IT'S ACCURATE

SIMPLEX®
VALVE AND METER COMPANY

This is the pipe
Courtney Allan

that's known as the

Taxpayers' Friend

To a tax-burdened public the statement that cast iron pipe is the "taxpayers' friend" is more than a mere figure of speech. To most waterworks engineers it is a cold fact. They know that cast iron pipe in water distribution systems has saved, and continues to save, millions of dollars in local taxes.

The useful life of cast iron pipe is known to be 4 to 5 times the average term of a water revenue bond issue. More than 35 American cities have cast iron mains in service that were installed over 100 years ago. A survey sponsored by three waterworks associations shows that 96% of all six-inch and larger cast iron pipe *ever laid* in 25 representative cities, is still in service.

Fortunately for taxpayers, over 95% of the pipe in America's water distribution systems is long-lived cast iron pipe—*the taxpayers' friend.*

This cast iron water main installed in Richmond, Virginia, 120 years ago, is still in service. Over 35 other cities have century-old cast iron mains in service.

CAST IRON

CAST IRON PIPE

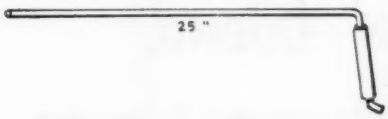
America's No. 1 Tax Saver

©1952, Cast Iron Pipe Research Association

CAST IRON PIPE RESEARCH ASSOCIATION, THOS. F. WOLFE, MANAGING DIRECTOR, 122 SO. MICHIGAN AVE., CHICAGO 3.

(*Continued from page 6*)

Pipe down—as deep at least as 20 ft and irrespective of type, size, or contents—may now be located accurately without muss or fuss by the use of simple equipment obtainable for as little as 50 cents. No, not mirrors—welding rods! The specifications: *Materials:* Two $\frac{1}{8}$-in. brass welding rods, 30 in. long, and two 4-in. lengths of $\frac{1}{4}$-in. copper tubing. *Fabrication:* Bend welding rods at 90-deg angle 5 in. from one end, then insert short section of one welding rod in each length of tubing and bend protruding end of rod to prevent tubing from slipping off (see cut). *Technique:* Using the tubing as handles, grasp one rod in each hand, with the long sections pointing forward, and "walk slowly at right angles with pipe to be located." *Characteristics of Operation:* When heels of operator's shoes are directly over the pipe, the 25-in. extensions will fan out in the direction of the pipe. *Accuracy:* Even at bends. *Power:* Rhabdomancy. *Caution:* Operator must not wear rubber boots.



We'd let it go at that, but we have some obligations in the matter. For instance, we owe last December's issue of the *Mueller Record* and its correspondent, J. J. Smyth of the Amherst (Ohio) Water Co., credit for first notice of this method of refining divining. We owe Supt. James W. Reilly of the Ware, Mass., Water Dept. considerable notice of his April claim to have invented what he calls his "douser." We owe the Massachusetts Dept. of Public Health credit for giving Reilly the opportunity to demonstrate his gadget (successfully) at a meeting of sewage system operators held in April in Amherst (Mass.). We owe the city of Northampton, Mass., credit for pioneering spirit in outfitting all its water department trucks with the equipment, and for optimism in expecting "to save thousands of dollars annually" by its use. We owe AWWA's New York Section a bow for wide-awake programming in managing to fit in a discussion and demonstration of this new boon at its Syracuse meeting, also in April. And, finally, we owe ourself the pleasure of at least a little speculation concerning the apparent realization of another pipe dream.

Excited as we are about the potentialities involved—especially for users of nonmetallic pipe, who, until now, have had all kinds of trouble in putting a finger on their unmapped lines—we have more than a qualm or two about the very lack of selectivity that permits the rods to line up concrete, tile, plastic, or wood pipe as well as metal lines. With no distinction made on the basis of pipe contents either, we're just a little worried about striking oil, or gas, or something even more ghastly. Meanwhile, documented proof of the "douser's" effectiveness to a depth of 20 ft in locating a "lost" sewer pipe actually impresses us—who slit our trenches much

(*Continued on page 12*)

Cutting Valve Costs for a lifetime

This interesting assembly consists of a 20 inch Rensselaer valve with reducing and increasing sections for installation in a 30 inch pipe line. The integral type gear case is designed for the working pressure of the valve and is packed with oil for lifetime service.

There is no need for a concrete vault for valves equipped with integral type gear cases. Just install valve boxes, shovel back the dirt and forget it, for this is the Rensselaer double disc valve with the well known wedge action. On closing, when the gates reach a position opposite their seats, the powerful wedging action presses them squarely and firmly against their seats. It is impossible to damage the stem threads or throw the stem out of alignment, and the gates open and close easily.

The valve you buy today should serve faithfully for many years. Why not provide maximum insurance against future maintenance costs by putting in Rensselaer valves in the first place?

Rensselaer VALVE COMPANY, TROY, N. Y.

GATE VALVES • FIRE HYDRANTS • SQUARE BOTTOM VALVES • CHECK VALVES • AIR RELEASE VALVES

A DIVISION OF NEPTUNE METER COMPANY

Sales representatives in principal cities

102

(*Continued from page 10*)

shallower—much less than the claim that "it will work for anyone"—clearly an attempt to dismysticize the operation in contradistinction to ordinary water divining, wherein twigs twitch only for properly endowed dowsers. Perhaps it's the broadness of "anyone"—even of "anyone not wearing rubber boots"—that gives us pause; perhaps it's the impracticability of thus taking to our heels over New York's network of pipes and cables; or perhaps it's just plain overexposure, but we must admit to a slight scoff if not a bad scold!

Dismystics are busy, too, attempting to unwitch water witching. Latest to explain was an almost-neighbor of Kenneth Roberts, one Haydn S. Pearson, for whom the wand worked once. Writing in the *Rural New-Yorker* of January 19, Pearson placed his faith in trace elements, suggesting that:

> . . . certain individuals have more of the trace elements in their living tissues than others. Some of these trace elements are in the soil; some are in the divining rod. The three areas combine, in a way we do not yet understand, to set up a magnetic field. The vein of water underground releases this magnetic tension circuit and the tension, in the hands of the right person, pulls the point of the divining rod earthward.

Why Haydn halted at trace elements when he had radioactivity right at hand, we can't be quite sure, but we have an idea it had something to do with the suspected tendency of radioactive divining rods to discover only heavy water.

In making another stab at the truth about dowsing, perhaps we ought to present our own theory, which is based entirely on the observation that the dowsing rod is usually cut in the shape of a wishbone. But that would tend more to dismiss than dismysticize—and perish the thought!

A laboratory technician is needed by a midwestern water utility to make routine chemical analyses and perform other analytical studies. Recent graduates or experienced personnel will be considered for the post, which pays $300 monthly or more, depending upon qualifications. Applicants should send details to the JOURNAL AWWA, Box 71.

R. M. Leggette, consulting ground water geologist of New York, has formed a partnership with M. L. Brashears, formerly of the U.S. Geological Survey. The firm, established under his own name by Leggette in 1944, will be known as Leggette & Brashears. The new partner joined the Geological Survey in 1936, working mostly in the New York and New England area, and in 1942 he was placed in charge of all ground water investigations in that region.

(*Continued on page 14*)

When you specify WARREN Cast Iron Pipe...

You're Right!

WARREN Cast Iron Pipe is available in all sizes from 2" to 84" . . . with all types of joints . . . special fittings in numerous non-standard patterns to help you meet unusual requirements.

You're Right!

WARREN Cast Iron Pipe combines all of the qualities necessary to assure long-life, trouble-free service, toughness and strength. Proper crushing, beam, shock and bursting strength have always distinguished WARREN Cast Iron Pipe.

SPECIFY WARREN CAST IRON PIPE
AND BE SURE!

Warren FOUNDRY & PIPE CORP.
55 LIBERTY STREET, NEW YORK 5, N. Y.

Bell & Spigot Pipe • Flange Pipe • Mechanical Joint Pipe
Flexible Joint Pipe • Short Body Bell & Spigot Specials

WARREN PIPE CO. OF MASS. INC. 75 FEDERAL ST. BOSTON, MASS.

95 Years of Continuous Service

(*Continued from page 12*)

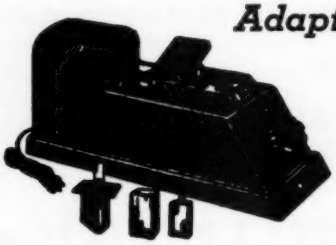
Some surplus office machines are being offered for sale by the City Purchasing Agent, Dept. of Purchasing, Room 162 City Hall, Cincinnati 2, Ohio. The equipment, which is all used, but in serviceable condition, includes three public utility billing machines, a supply of roll paper, and an addressing and printing machine.

Morris M. Cohn, city manager of Schenectady, N.Y., and editor of *Wastes Engineering,* has been awarded the honorary Doctor of Science degree by Union College, Schenectady, in an unusual family-style degree-awarding ceremony held June 8. His son, Jay, is president of the June graduating class at the college.

A computer for use in determining quantities of coal-tar enamel in pounds per 1,000 ft and primers in gallons per mile for pipe in sizes from 2 in. to 48 in. is available from Reilly Tar & Chemical Corp., 1615 Merchants Bank Bldg., Indianapolis, Ind. Quantities of compound required for mechanical couplings in the same size range are also supplied. A slide rule on the reverse of the calculator is fitted with a plastic hairline scale. Requests should be made on business stationery.

(*Continued on page 16*)

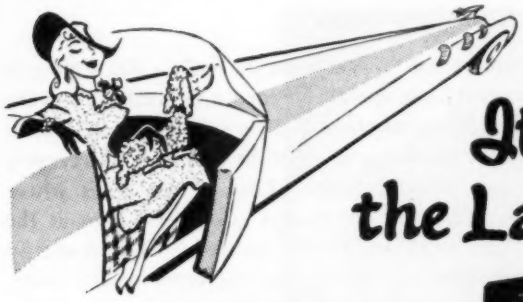
KLETT SUMMERSON
ELECTRIC PHOTOMETER



Adaptable for Use in Water Analysis

Can be used for any determination in which color or turbidity can be developed in proportion to substance to be determined

KLETT MANUFACTURING CO.
179 EAST 87th STREET · NEW YORK, N. Y.



It's the Last Word!

FEATURES

HIGH ACCURACY: The Gravimetric Fluoridizer will deliver within ½ of 1% of the rate for which it is set, regardless of the amount of material in the hopper, or changes in density of the chemical being fed.

NON-FLOOD FEEDING MECHANISM: Sodium Fluoride or Sodium Silicofluoride cannot escape through the Rotolock feeding mechanism which provides positive control and insurance against excessive dosage.

TREATMENT RECORDED: A totalizer shows the total number of pounds of chemical delivered by the feeder, thereby providing an accurate record of fluoride treatment, and a check against inventory.

SENTINEL ALARM: The sentinel alarm will warn the operator if the hopper becomes empty or if there is any deviation from proper rate of feed.

EFFICIENT DISSOLVER: Dissolving Chambers are selected and sized for each specific application and installation to insure maximum efficiency.

OMEGA
Gravimetric
(Weighing)
Fluoridizer

For complete information and Bulletin 30-H21 describing Omega Gravimetric Fluoridizer, address Omega Machine Company (Division of Builders Iron Foundry), 365 Harris Ave., Providence 1, Rhode Island.

B·I·F INDUSTRIES

OMEGA
The Last Word in Feeders

Ω OMEGA

(*Continued from page 14*)

No dissatisfied customers can be the claim of Kelly's Rat Cafeteria despite the fact that it serves its one specialty—corn a la warfarin—every day of the week. Even though restaurateur Kelly's success depends upon slow but sure poisoning of his customers, however, he still finds it necessary to attract them before he can subtract them. That, of course, is where water comes in—for, for water, there are always customers, even at the city dumps where Kelly's cafeterias are usually located. Tests made by the Solvit Chemical Co., of Madison, Wis., manufacturers of the units, have shown that rat cafeterias equipped with a water supply attract and then reattract 30 per cent more rats than those not providing water. And since this 30 per cent increment is drawn only from rats who have taken the trouble to go inside one of Kelly's places to find out for themselves if they can get a drink, it is clear that advertisement of the attraction would make the difference even greater. A dignified sign—"Water Served to Lady and Gentleman Rats"—might do the job, but how much more certain a change of name to "Kelly's Sip 'n' Sup"?

Not just better rat traps, though—the best rat bait, too—is receiving more than its share of inventors' attention these days. Out at Kansas City, Professors Howe and Langelier of the Univ. of California reviewed methods of converting sea to potable water. The federal government, the Conservation Foundation, and a host of agencies, organizations, and individuals of various interests are busy at work on that task. Meanwhile, others are just as assiduously seeking other means of making more fresh water more available. To leave no stone unturned, we can't take the chance of ignoring two sort of shining hopes that just appeared from wintering in California and in Florida.

First, from Redondo Beach, came word that 79-year-old Claude Inman has patented a geyser, with the idea of using its power as cheap fuel for sea water distillation. The idea came to Claude in a splash somewhere in the Sandwich Islands, and, since his retirement, he has been able to develop a device that imitates the waves pounding into a coral cave and spouting out a small escape hole. Merely by tilting his hand-operated wavemaker model he can make 5 gal produce 35 psi. Now all he needs is a permanent wave, which, he estimates, will cost some $250,000 to build.

Then, from Tampa, came something less well defined, but certainly more "promising." There it was one Otto S. Wollenschlager who made this "Announcement to Industry and Research":

I, an INVENTOR, have recently originated a METHOD and DEVICE to EXCHANGE HEAT, REVOLUTIONARY in principle, BASIC in application. The device has SCORES OF APPLICATIONS, PATENT APPLIED FOR,

(*Continued on page 18*)

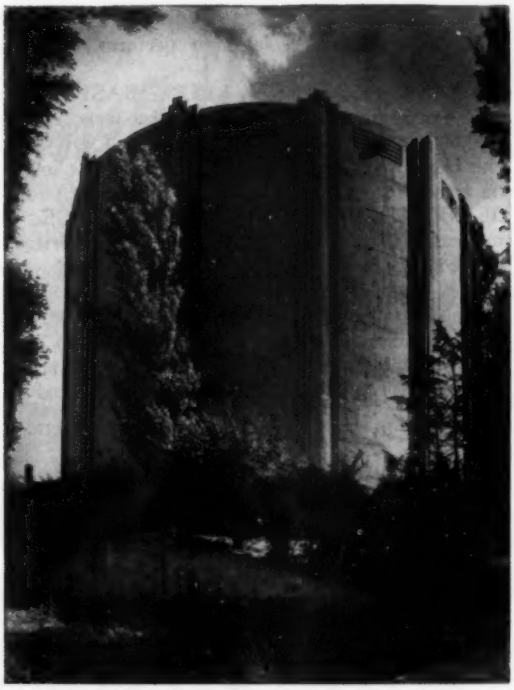


Photo shows 675,750 gal. water tank of Waukesha, Wis. Water Utility. Built in 1934, it has needed no maintenance. Architect: M. F. White. Structural engineer: W. S. Hewett.

To give your city a water tank of distinction . . . choose *CONCRETE*

A well-designed water tank such as shown above not only has long-lasting utility but its beauty makes it an outstanding landmark as well. Any city, large or small, can benefit by building such a reinforced concrete water tank. Its durability and enduring beauty make it a structure of which the entire community can be proud.

Reinforced concrete water tanks can be placed in practically any location without marring the skyline or depreciating the value of the property in the area.

Best of all, reinforced concrete water tanks are more economical than other types for they require a minimum of maintenance and last much longer. They give true ***low-annual-cost*** service, which pleases water works officials, engineers and taxpayers alike.

PORTLAND CEMENT ASSOCIATION

33 W. Grand Ave.
Chicago 10, Ill.

A national organization to improve and extend the uses of portland cement and concrete through scientific research and engineering field work

(*Continued from page 16*)

using known physical laws to perform work in a WAY NEVER YET DEVISED.

The TASK is to develop my CRUDE BASIC state of art into a perfected device. This would involve skills, laboratory, tests, etc.—involving an expenditure of $100,000 or more—for ultimate PROFIT OF MILLIONS.

The U.S. Government has been solicited, the invention being presented to them via armed forces (office of technical services.) for use as device to RECOVER DRINKING WATER from SNOW and ICE. They, the Government, communicated to the writer that they found merit and would be interested in a PERFECTED state of my invention, if and when proven superior to known devices.

Therefore, large GOVERNMENT CONTRACTS are possible.

I seek an agreement with a large company to develop my device in all phases. Are you interested? If so, please reply, stating your terms, interests and abilities.

What price rat bait, indeed! Or, in one man and Wollenschlager.

Unincorporated fringe areas were annexed by 309 cities during 1951, according to *Public Management*, the journal of the International City Managers' Assn. Areas annexed ranged from 82 sq miles acquired by Atlanta, Ga., down to fractions of a square mile. Almost half of the annexing cities were in the state of California or Texas.

(*Continued on page 20*)

KUPFERLE

On their reputation for performance, Kupferle Fire Hydrants deserve consideration for any installation.

Full lines for public and private installations.

Send for Specification sheets.

JOHN C. KUPFERLE FOUNDRY CO.
ST. LOUIS

ANTHRAFILT
(Reg. U. S. Pat. Off.)

As a Modern Filter Medium Has Outstanding Advantages Over Sand & Quartz Media

1. Length of filter runs doubled
2. Only about one half as much wash water required
3. Less coating, caking or balling with mud, lime, iron or manganese
4. Filters out of service less because of shorter wash cycle
5. Better removal of bacteria, micro-organic matter, taste and odor
6. Increased filter output with better quality effluent
7. Not just the top portion, but the entire bed aids in filtering
8. Can be used in all types of filters using a filter media
9. A perfect supporting media for synthetic resins
10. An ideal filter media for industrial acid & alkaline solutions
11. Decidedly advantageous for removal of fibrous material as found in swimming pool filters

Additional information, recommendations and quotations furnished upon request by

Palmer Filter Equipment Company
823 East 8th Street. P.O. Box 1655
Erie, Pennsylvania

representing

Anthracite Equipment Corporation
Anthracite Institute Building,
Wilkes-Barre, Pennsylvania

For Faster Installations ...RAIN or SHINE

CLOW
Mechanical Joint
Cast Iron Pipe, Fittings and Valves

Clow Mechanical Joint
A time-saving, easily installed mechanical joint cast iron pipe that reaches the job complete with all joint materials. Sizes 3" to 24" in 18-foot lengths.

It's always "fair weather" when you install Clow Mechanical Joint Cast Iron Pipe, Fittings and Valves. Even in a wet trench or under water, ordinary workmen can quickly do the job with ratchet wrenches. No calking needed. And once installed, this pipe line is set for a century or more of service. Each joint is sealed "bottle-tight" by a heavy molded rubber gasket—yet stays flexible to compensate for vibration, expansion or contraction. "Standardized" parts is another feature . . . glands, bolts and gaskets are completely interchangeable.

CLOW MECHANICAL JOINT CAST IRON FITTINGS

Mechanical Joint 90° Elbow

All types offered in straight and reducing sizes for use with Clow Mechanical Joint Cast Iron Pipe.

Mechanical Joint Tee

CLOW FOUNDRIES are fully equipped to produce Bell and Spigot cast iron pipe, fittings, valves and many pipe line specials.

EDDY MECHANICAL JOINT GATE VALVE

Workmen can quickly install these valves, using just a ratchet wrench to make up the joints pressure-tight. Weather is not a problem—for no calking or lead melting is necessary. Available in sizes 3" to 12" for use on both centrifugally cast and sand-cast iron pipe.

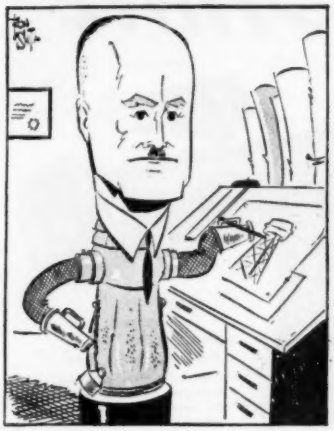
JAMES B. CLOW & SONS
201-299 North Talman Avenue • Chicago 80, Illinois
CAST IRON

and their National Cast Iron Pipe Division, Birmingham, Alabama; subsidiaries: Eddy Valve Co., Watertord, New York; Iowa Valve Co., Oskaloosa, Iowa

(*Continued from page 18*)

Honors all over the place are falling to AWWAers—and deservedly so. As a matter of fact, it's just about time people realized what VIPs AWWA produces. Take Dean Stapleton, for instance, or Mr. Efficiency, or Dr. Capen—three just honored for their public service, and about time too after a total of 118 years of service to their present employers.

It is John E. Stapleton actually—"Dean" just means that he has served the Auburn, N. Y., water department for 50 years, and it was his golden anniversary that brought out Mayor and Council to present him a watch and to do him honor for a "sunny disposition" maintained despite the fact that as Treasurer it was his duty to collect payment of the water bills. The local newspaper, too, did him proud in both story and editorial.



And if you haven't recognized "Mr. Efficiency" from his caricature, you must have missed meeting W. Elwood MacDonald, Commissioner of Water Works at Ottawa, Ont. It was the occasion of Mr. E's receipt of the Canadian Section's Fuller Award at KC upon which both Ottawa newspapers seized to give him a full introduction and tribute in the public prints. In part, the significance of the hydrant must be its "No Parking" implication, for certainly in his past three years as AWWA Director from Canada, Mr. E could have wasted no time at rest.

Finally, don't let the "Doc" throw you, it's still the same old Charlie Capen who at KC was left holding the Presidential gavel. The Doc refers to the honorary degree of Doctor of Engineering conferred upon him by the Newark College of Engineering at its June commencement exercises.

To all three—and to all others whose lights we haven't yet unbusheled —formal felicitations, convivial congratulations, and nice going!

Claude S. Lawson has been elected president of U.S. Pipe & Foundry Co., succeeding Norman F. S. Russell, who had occupied the post since the resignation of Donald Armstrong last December, and now relinquishes it to be reelected chairman of the board. James J. Reynolds was simultaneously elected vice-president of the firm.

Robert J. La Fortune has been appointed representative of Reilly Tar & Chemical Corp. in the Oklahoma, Arkansas, and Colorado territory.

(*Continued on page 78*)

PLODDING ALONG WITH YOUR WATER SOFTENING SYSTEM?

Not if it contains AMBERLITE IR-120 cation exchange resin. Here's how to check the performance of your present softener:

Check its capacity. AMBERLITE IR-120 has an average operating capacity of 30,000 grains of hardness per cubic foot, even at peak flow rates of 10 gal./sq. ft./min.

Check regeneration costs. AMBERLITE IR-120 thrives on a salt-starvation diet of as little as ¼ pound per 1,000 grains of hardness removed.

Check service efficiency. AMBERLITE IR-120 gives years of trouble-free service without attrition losses—is stable to waters of low silica content, oxidizing and reducing agents—can be operated safely over the entire pH range and at elevated temperatures. A typical AMBERLITE IR-120 unit has delivered almost 5,000,000 gallons of softened water per cubic foot of resin *without measurable capacity or attrition losses.*

CHEMICALS FOR INDUSTRY

Ask your water-treating equipment supplier or your consulting engineer about AMBERLITE IR-120. Meanwhile be sure to write Dept. W-1 for full technical data.

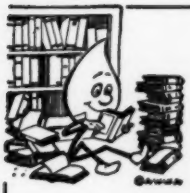
ROHM & HAAS COMPANY

THE RESINOUS PRODUCTS DIVISION

Washington Square, Philadelphia 5, Pa.

Representatives in principal foreign countries

AMBERLITE *is a trade-mark, Reg. U.S. Pat. Off. and in principal foreign countries.*



The Reading Meter

Boiler-Water-Treatment Manual for Federal-Plant Operators. *Louis Goldman. Handbook 5, Bureau of Mines (1951) 94 pp., paperbound; 40¢ from Supt. of Documents, U.S. Government Printing Office, Washington 25, D.C.*

Intended for boiler plants run at pressures of 300 psi or less and ratings up to approximately 200 per cent, this manual discusses the working principles of boiler water treatment and their application. Internal treatment is dealt with primarily, as being more appropriate to the usual small boiler. The discussion includes sections on maintenance of causticity, scale control, the use of quebracho tannin, corrosion control, blowdown and carryover, and sampling and analysis.

Municipal Index—1952. *American City Magazine Corp., 470 Fourth Ave., New York 16, N.Y. (1952) 915 pp. (including advertising); $5.00*

Another edition of the annual guide to top municipal officials (including water works superintendents), in communities of more than 10,000 population, products of interest to municipal purchasers, and the fundamentals of municipal operation. A 128-page Rand McNally atlas is bound into the volume to furnish state maps and 1950 population statistics.

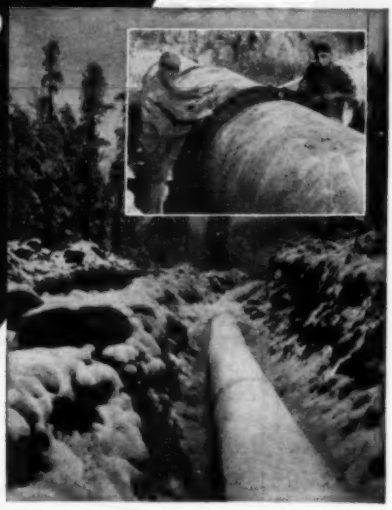
Water Resources of the Detroit Area, Michigan. *C. O. Wisler, G. J. Stramel, and L. B. Laird. Circular 183, Geological Survey, Washington, D.C. (1952) 36 pp., maps; paperbound; free*

This report on the water supply in a critical industrial area is in general optimistic in tone, indicating that only 2.5 per cent of the average flow of the Detroit River—the area's major source of supply—is currently being used. Most of the region's 3,100,000 population is concentrated in Detroit, but the national pattern of greater growth in the communities beyond the city limits applies to this area also. Although local shortages may be caused by system inadequacies, no serious shortage of water at the source is anticipated.

(Continued on page 82)

DENVER, COLO.—At 9,400 ft. elevation and 10° temperature, construction of Denver's new 54" Ranch Creek line went forward with steel pipe joined by Dresser Couplings. The line carries water to the Moffat Tunnel to help provide for Denver's rapid growth.

A DRESSER-COUPLED STEEL LINE delivers water cheaper



No matter if your problem is terrain . . . weather . . . labor . . . or time . . . the cheapest way to deliver water to the place where it turns into revenue is with a Dresser-Coupled steel line. It's the experienced engineer's way to get a superior line and still reduce *installation* and maintenance costs . . .

Once you have discovered the ease of construction of such a line, you'll know why more and more engineers specify them every year. Long, strong sections of steel pipe are easily put in place and quickly joined with factory-made, virtually foolproof Dresser Couplings. Construction proceeds rapidly even over rugged terrain like that shown here.

Leakage losses are eliminated. *Controlled gasket pressure*, provided by the bolting-up process in a Dresser Coupling, is your assurance of the correct *sealing* pressure all around the joint. Resilient Dresser gaskets absorb stresses from vibration, contraction and expansion, yet keep the joint "flexible-tight".

Maintenance is cut to the bone, too. Dresser Couplings last for life, and the absence of heat in joining prevents damage to glass-smooth pipe linings. High carrying capacity is sustained.

Experience all over the world proves that a Dresser-Coupled steel line gives you the ultimate in performance and economy. See your Dresser Sales Engineer or write our Bradford Office for literature.

Be Sure you, too, get the best line at the best price. Put steel pipe and Dresser Couplings in your specifications.

DRESSER

"FLEXIBLE-TIGHT"

COUPLINGS

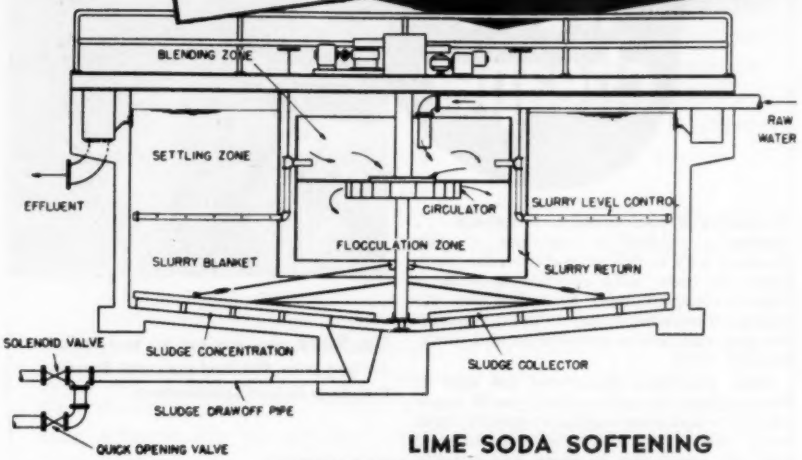
Dresser Manufacturing Division, 59 Fisher Ave., Bradford, Pa. (One of the Dresser Industries). Warehouses: 1121 Rothwell St., Houston, Texas; 101 S. Bayshore Highway, South San Francisco, California. Sales Offices: New York, Philadelphia, Chicago, Houston, South San Francisco. In Canada: 629 Adelaide St., W., Toronto, Ont.

American FLOCSETTLER

PROVIDES COMPLETE, EFFICIENT

WATER CONDITIONING

COMBINES IN ONE UNIT
1. RAPID MIX
2. FLOCCULATION
3. SETTLING
4. SLUDGE REMOVAL



LIME SODA SOFTENING
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Ambrioso Cuza, Erasmo, Captain of Engrs., Gen. Staff, Cuban Army, Robau 308 Altos, Buen Retiro, Marianao, Havana, Cuba (Apr. '52) *M*

Andrews, Alton R., Mgr., Oregon Water Corp., Box 407, Roseburg, Ore. (Apr. '52)

Armstrong, Luther Williams, Service Engr., Builders Iron Foundry, Box 891, Seahurst, Wash. (Apr. '52) *MPR*

Bannecker, W. R., *see* King County Water Dist. No. 7 (Wash.)

Barro Segura, Juan, Constr. Engr., Marianao Waterworks, Comision de Fomento Nacional, Calle 23 No. 1003, Vedado, Havana, Cuba (Apr. '52) *MR*

Berhow, Donald D., Treatment Plant Operator, Water Dept., Webster City, Iowa (Apr. '52) *P*

Bohmann, George, Chem. Control Engr., South Dist. Filtration Plant, 3300 E. Cheltenham Pl., Chicago 49, Ill. (Apr. '52)

Brantley, Nall, *see* Forrest City (Ark.) Water & Sewer Dept.

Bruner, Henry F., Asst. Chemist, Board of Public Utilities, Kansas City, Kan. (Apr. '52) *P*

Chapman, Elmer, Supt., Board of Public Utilities, 1937 N. 31st St., Kansas City 2, Kan. (Apr. '52) *M*

Cleaver, Walter, Supt., Water Works, 184 E. 4th St., Brookville, Ind. (Apr. '52) *M*

Cooper, James W., Asst. Mgr., Water Sales Div., Water Dept., 425 Mason St., San Francisco 1, Calif. (Apr. '52) *M*

Crothers, Abner G., Repr., Williams Gauge Co., 4108 C St., Little Rock, Ark. (Apr. '52) *M*

Derrick, Herbert L., Water Supt., Ontario, Ore. (Apr. '52) *M*

Dollar, P. A., Contractor, Morrilton, Ark. (Apr. '52) *M*

Douglas, James B., Administrative Asst., Water Dept., Municipal Bldg., Oklahoma City, Okla. (Apr. '52) *M*

Fairbanks Co., The, Edward T. Adams, Product Engr., 393–399 Lafayette St., New York 3, N.Y. (Assoc. M. Apr. '52)

Forrest City Water & Sewer Dept., Nall Brantley, Mgr., Forrest City, Ark. (Mun. Sv. Sub. Apr. '52) *MP*

Fox, Albert J., San. Engr., W. T. Hooper, Jr., Cons. Engrs., 804 Belvidere St., Waukegan, Ill. (Apr. '52) *PR*

Fuller, Miles Lavern, Office Engr., Water Dept., 129 N. 2nd St., Yakima, Wash. (Apr. '52) *M*

Goicoechea Cosculluela, Emilio, Civ. Engr., Comision de Fomento Nacional, Calle 23 entre 4 y 6, Vedado, Havana, Cuba (Apr. '52) *M*

Grandbois, C. L., Supt., Water Works, 3 Main St., Jackson, Calif. (Apr. '52)

Harford, Walter C., Mgr., Concrete Conduit Co., Box 2670, Phoenix, Ariz. (Apr. '52)

Hicks, Jay C., Water Supt., McKenzie Highway Water Dist. & Rainbow Water Dist., Box 701, Springfield, Ore. (Apr. '52) *M*

Hollmeyer, Lewis H., Contracting Engr., Chicago Bridge & Iron Co., 1318—4th Ave., Seattle 1, Wash. (Apr. '52)

Howe, M. W., Dist. Mgr., Wallace & Tiernan Ltd., 301 Hamilton Bldg., Winnipeg, Man. (Apr. '52)

Jimenez Lopez, Cesar, Cons. Engr.-Secretaria de Recursos Hidraulicos, Comision Hidrologica del Valle de Mexico, Ayuntamiento 146, Mexico D.F., Mexico (Apr. '52) *M*

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Jowers, Afton Bradford, San. Engr., Polk, Powell & Hendon, 618 Stallings Bldg., Birmingham, Ala. (Apr. '52) *P*

Kahrs, William H., Pres., Manhattan Water Meter Repair Co., Inc., 431 E. 76th St., New York 21, N.Y. (Apr. '52) *M*

Kalb, Edward F., Supt., Water & Sewer Com., Trumann, Ark. (Apr. '52) *MR*

Kempe, Clifford G., Supt., Lakewood Water Dist., 11920 Gravelly Lake Dr., Tacoma, Wash. (Apr. '52) *MR*

King County Water Dist. No. 7, W. R. Bannecker, Supt. & Mgr., 8800 Bothell Way, Seattle 5, Wash. (Corp. M. Apr. '52) *MPR*

Kisiel, Chester Carl, San. Engr., Western Air Defense Force, Air Surgeon's Office, Hamilton Air Force Base, Calif. (Jan. '52) *MPR*

Klein, Paul, Plant Operator, Water Dept., 12340 N.E. 8th Ave., North Miami, Fla. (Apr. '52) *MP*

Knaggs, Reginald H., Asst. Utilities Engr., State Public Utilities Com., 145 S. Spring St., Los Angeles, Calif. (Apr. '52)

Kosciusko Light & Water Plant, W. A. Lewis, Mgr., Kosciusko, Miss. (Corp. M. Apr. '52) *MPR*

Lane, Harold L., Supt., Water Works-Sewerage Disposal, Water Com., Box 146, Norris, Tenn. (Apr. '52) *M*

Larkin, Kenneth H., Cons. Engr., Kenneth H. Larkin & Assoc., 3102 Troost St., Kansas City, Mo. (Apr. '52) *PR*

Lewis, W. A., *see* Kosciusko (Miss.) Light & Water Plant

Livesay, D. P., A. K. Stillman Cons. Engrs., 201 Chambers Bldg., Olympia, Wash. (Apr. '52) *MPR*

McPhee, Walter T., Assoc. Engr., Malcolm Pirnie Engrs., 25 W. 43rd St., New York 36, N.Y. (Apr. '52) *PR*

Miller, Byron Monroe, Business Mgr., La Mesa, Lemon Grove & Spring Valley Irrigation Dist., 4769 Spring St., La Mesa, Calif. (Apr. '52) *M*

Montgomery, James A., Engr., R. H. Brown & Co., 620 Henry Bldg., Portland, Ore. (Apr. '52) *P*

Montiel G., Fernando J., 3a Calle S.E. No. 613, Managua, Nicaragua (Affil. Apr. '52) *MP*

Nery, Raymond J., *see* North Carolina Utilities Com.

North Carolina Utilities Com., Raymond J. Nery, Utilities Engr., Raleigh, N.C. (Corp. M. Apr. '52)

Paulette, Charles Harvey, San. Engr., Commonwealth Assocs., Inc., Hayes St., Jackson, Mich. (Apr. '52) *MPR*

Peters, Ernest, Jr., Chemist, Elizabethtown Water Co., 420 W. Jersey St., Elizabeth, N.J. (Apr. '52) *P*

Pfeifer, John C., Water Supt., Public Utilities Dist., Route 5, Box 1193D, Vancouver, Wash. (Apr. '52) *M*

Pitman, Raymond F., Contractor-Owner, Pitman Contracting Co., 300 W. 79th Terrace, Kansas City, Mo. (Apr. '52) *M*

Preston, Frederick S., Gen. Supt., Pitman Contracting Co., 300 W. 79th Terrace, Kansas City, Mo. (Apr. '52) *M*

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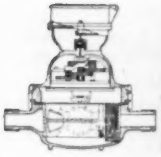

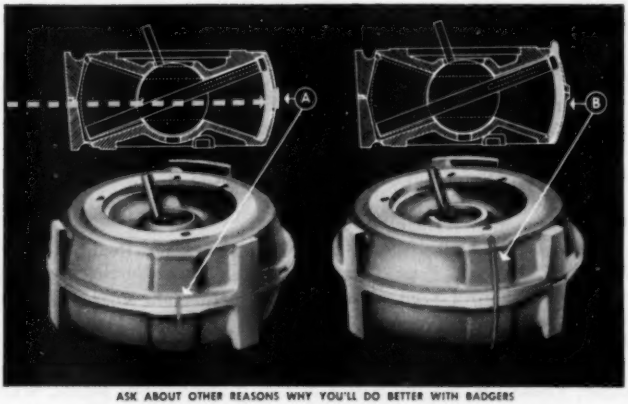

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Robison, Arch, Director of Service & Safety, City Engr., Celina, Ohio (Apr. '52) *M*

Rocheleau, Robert F., Exec. Secy.-Engr., State Water Com., Charleston, W. Va. (Apr. '52) *R*

Schroeder, Marvin H., Supt., Dept. of Sewers & Treatment Plant, City Hall, Vancouver, Wash. (Apr. '52)

Seaboldt, Edward I., Supt., Town of Cortlandt Water Dists., Verplank, N.Y. (Jan. '52) *M*

Sherrill, Loren J., Asst. Mgr., Coos Bay-North Bend Water Board, 264 S. Broadway, Coos Bay, Ore. (Apr. '52) *M*

Shupe, Larry Dean, Sales Engr., Layne-Arkansas Co., 120 W. 2nd St., Stuttgart, Ark. (Apr. '52) *PR*

Sylvan, Matthew Donald, Engr., Kansas City Suburban Water Co., Inc., 5916 Dearborn St., Mission, Kan. (Apr. '52) *M*

Tanaka, Kanshichi, Mng. Director, Kubota Iron & Machinery Works, Osaka, Japan (Apr. '52)

Tetyak, John J., Pres., Tetyak Young Const. Co. & Tulsa Const. Co., 7328 W. 80th St., Overland Park, Kan. (Apr. '52) *MR*

Thompson, L. E., Distr. Supt., Water & Gas Dept., Iola, Kan. (Apr. '52) *MR*

Trenton Board of Public Affairs, Howard Woodrey, Supt., Water Works, 436 E. State St., Trenton, Ohio (Mun. Sv. Sub. Apr. '52) *MP*

White, E. L., Water Supt., Port Orford, Ore. (Apr. '52) *M*

Willey, Kenneth W., Engr., Wilson & Co. Engrs., Salina, Kan. (Apr. '52) *PR*

Wood, M. L., San. Engr., State Water Pollution Control Com., State Health Bldg., Little Rock, Ark. (Apr. '52) *PR*

Woodrey, Howard, *see* Trenton (Ohio) Board of Public Affairs

Yager, Leslie, Jr., Supt., Water & Gas Dept., Nebraska City, Neb. (Apr. '52)

Young, Arthur P., Vice Pres., Tetyak Young Const. Co. & Tulsa Const. Co., 7328 W. 80th St., Overland Park, Kan. (Apr. '52) *M*

Zbinden, Ernest, Engr., Eng. Div., 3161 Joseph St., Montreal 19, Que. (Apr. '52)

REINSTATEMENTS

Hill, Oscar E., Mgr., Idaho Water Co., 114 S. 4th St., Coeur d'Alene, Idaho (Apr. '44) *M*

Sharp, Perry Clifford, Design Engr., Charles A. Haskins, Cons. Engr., 800 Finance Bldg., Kansas City, Mo. (Jan. '44) *PR*

CHANGES IN ADDRESS

Changes received between May 5, and June 5, 1952

Carter, Jay B., 5014½ Mt. Royal Drive, Los Angeles 41, Calif. (Jan. '49) *MPR*

Chandler, Sydney W., Civ. Engr., Biggs, Weir & Chandler, 336 Meadowbrook Rd., Jackson, Miss. (Jan. '51) *P*

Darling, Charles, *see* Grand Rapids (Mich.) Water Works

Daugherty, A. B., 2880 Cass St., East Gary, Ind. (Jan. '41)

Denize, Clement, 17 Ave. Ducoste, Port-au-Prince, Haiti (July '49) *MP*

Dibdin, Frederick J. A., Cons. Engr., 404 Millavdon St., New Orleans 15, La. (Jan. '49)

Fiesler, Frederick, 145 E. High St., Edwardsville, Ill. (Jan. '44) *MP*

Gansler, William G., Sales Engr., Dresser Mfg. Co., Ltd., 163 Bellechasse St., Montreal, Que. (Jan. '51)

Gouin, Paul, Supt. of Filtration Plant, 100 W. St. Charles St., Longueuil, Que. (Apr. '41) *P*

Grand Rapids Water Works, Charles Darling, Monroe & Coldbrook Sts., N.W., Grand Rapids, Mich. (Corp. M. Feb. '13)

Haestad, Roald, Cons. Engr., Box 61, Great Barrington, Mass. (Apr. '51)

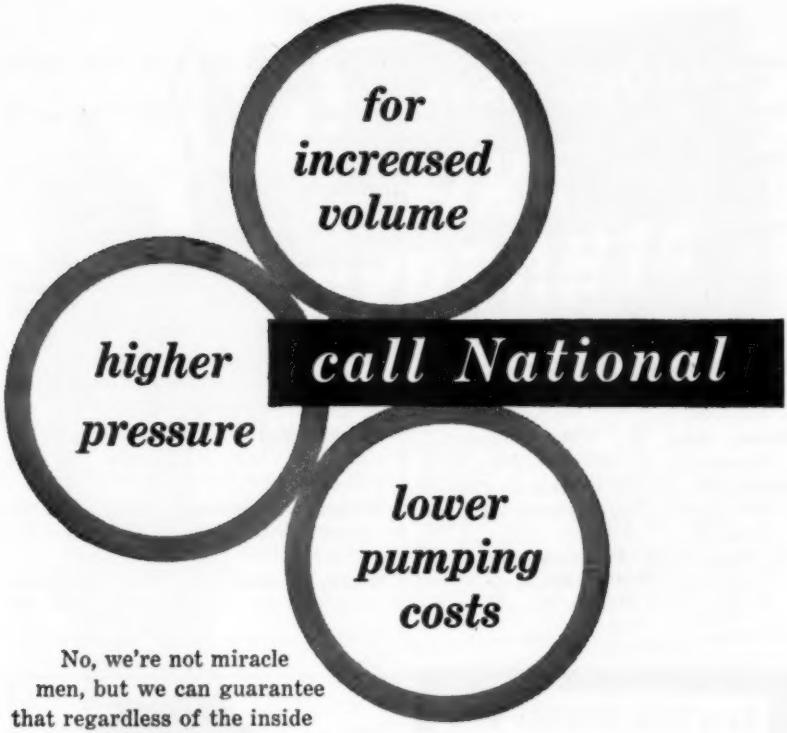
Honolulu Board of Water Supply, E. J. Morgan, Mgr. & Chief Engr., Box 3410, Honolulu 1, Hawaii (Corp. M. Nov. '30) *MPR*

Hot Springs Munic. Water System, N. F. Lund, Gen. Mgr., Hot Springs National Park, Ark. (Corp. M. Mar. '20) *MP*

Kinser, Richard E., U.S. Tire & Rubber Co., 325 Berkley St., Indianapolis, Ind. (Jan. '52) *P*

Krassy, Charles M., Oakland Park, Fla. (Jan. '37) *M*

(*Continued on page 36*)



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(*Continued from page 34*)

Lasaga, Andres, Quemadea Num. 239, Mexico 12, D.F., Mexico (Jan. '43) *P*

Lund, N. F., *see* Hot Springs (Ark.) Munic. Water System

Martinez, J. E., Asst. Prof., Civ. Eng. Dept., Univ. of New Mexico, Albuquerque, N.M. (Oct. '50)

Morgan, E. J., *see* Honolulu (Hawaii) Board of Water Supply

Pittsburgh Coke & Chemical Co., N. T. Shideler, Protective Coatings Div., 1905 Grant Bldg., Pittsburgh 19, Pa. (Assoc. M. July '49)

Poole, George M., Eli Lilly & Co., 740 S. Alabama St., Indianapolis, Ind. (July '51) *MP*

Propst, John M., 7209 Linden Rd., Kansas City 15, Mo. (Jan. '36) *MPR*

Riddle, W. G., c/o Charles A. Haskins, 800 Finance Bldg., Kansas City, Mo. (Jan. '51)

R. Stuart Royer & Assocs., Edward H. Ruehl, 401 Virginia Bldg., Richmond 19, Va. (Corp. M. Jan. '48) *P*

Ruehl, Edward H., *see* R. Stuart Royer & Assocs.

Shideler, N. T., *see* Pittsburgh Coke & Chemical Co.

Smith, Jack F., Engr.-Mgr., Dallas County Park Cities Water Control & Improvement Dist. 2, 8527 Hines Blvd., Dallas, Tex. (Jan. '48) *M*

Smith, John C., Asst. Chief, Water Supply Div., Corps of Engrs., Washington Dist., 1st & Douglas Sts., N.W., Washington 25, D.C. (Jan. '49) *MP*

Smith, W. E., Dist. Mgr., Wallace & Tiernan Co., Inc., 8779 Grand River Ave., Detroit 4, Mich. (Jan. '38)

Stilwell, Neil C., Soft Water Service-Kokomo, 1124 E. Monroe St., Box 752, Kokomo, Ind. (Jan. '46) *P*

Williamson, Edward, Mgr., Downey County Water Dist., 8244 E. 2nd St., Downey, Calif. (Oct. '39)

Yocum, George H., Gen. Foreman, Ravenna Arsenal, Apco, Ohio (Oct. '45)

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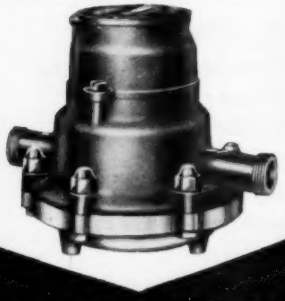

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SWIMMING POOLS

Bacterial Evolution of the Water in an Untreated Swimming Pool. Special Case of a Swimming Pool Supplied With Ferruginous Water. G. V. BENEDEN. Bul. Centre Belge Et Doc. Eaux (Belg.), No. 10:595 ('50). Changes in the bact. flora in a swimming pool in which the water was not treated were investigated. The pool, which is used for about 6 hr daily, is filled with water, and each day sufficient hot water is added to maintain a temperature of 25 C. After 3 weeks the pool is emptied completely and refilled with fresh water. The water is soft, with a pH value of 6, is free from calcium and contains few dissolved salts, but has traces of dissolved iron and a little organic matter. Sometimes the water used to fill the pool is clear; this water becomes turbid after approx. 3 days and turbidity increases during the period of use. The contents of total bact. and of *Esch. coli* are high. A greyish deposit forms at the bottom and on this develop algae, *Paramoecium,* and infusoria. At other times the water entering the pool is cloudy and yellow owing to the presence of a colloidal suspension of limonitic clay. The turbidity persists for 3 or 4 days and then a brown floc forms and settles to the bottom of the pool, leaving the water clear. The number of bacteria increases at first and then remains constant or decreases. *Esch. coli* are seldom found. The brown deposit contains algae, *Paramoecium,* infusoria, and iron bacteria, such as *Spirophyllum* and *Leptothrix,* which act as heterotrophic organisms and live on the organic matter present in the water. It is thought that pathogenic bacteria are removed from the water in the floc. In both cases ammonia, nitrites, and nitrates are absent.—*WPA.*

The Purification of the Water of Swimming Baths. MINISTRY OF HEALTH. H. M. Stationery Office, London ('51). 36 pp. The 2nd ed. of this report includes a more concise discussion of the types of poln. found in the water of swimming baths and of the dangers of transmission of infection than did the 1st ed. published in 1929. A description of an apparatus for measuring the clarity of the water has been added. A considerably fuller acct. is given of the chemistry of chlorination of water, including a discussion of the advantages of breakpoint chlorination. Addnl. methods described for the detn. in water of free and combined chlorine include the *o*-tolidine-arsenite test, and the use of *p*-aminodimethylaniline and of neutral *o*-tolidine. The use of ozone for the disinfection of water is discussed briefly.—*WPA.*

Swimming Bath Water Purification. E. G. WHITE. Pub. Health, Johannesburg (S. Afr.), 13:149, 159 ('49). Methods commonly used for the treatment of water for swimming baths are described briefly.—*WPA.*

Treating Water. E. R. WILLIAMS & E. E. WILLIAMS. U.S. Patent 2,543,-

(*Continued on page 40*)

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(Continued from page 38)

562 ('51). When water is softened with a mixt. of hydrocarbon sulfonate, sodium sulfate, and sodium silicate, the retention of chlorine in water supplies is improved if the hydrocarbon product contains 1½–7% sodium sulphate; 7–14% sodium sulphate reduces frothing, discourages algae in swimming pools, and diminishes irritation to the eyes of bathers.—*WPA.*

FLUORIDATION

The Optimum Vehicle for Fluoridation—Water or Milk. J. E. McKee. J. Maine Wtr. Utils. Assn., 28:2:42 (Mar. '52). Principal objections to fluoridation of water include: high cost; limited supply of fluoride compounds; small proportion of water consumed by children; "mass-medication"; and variable water consumption by children. Overcoming these objections best accomplished by adding fluorides to milk. Assimilation of milk-borne fluorides claimed to be same as water-borne. Quantities and variations of milk consumption claimed to be more constant than water. Palatability and nutritional value of milk claimed to be unaffected by added fluorides. Cost would be much lower, and acceptance by families with small children would be obvious.—*F. J. Maier.*

Engineering Problems in Water Fluoridation. F. J. Maier. Am. J. Pub. Health., 42:3:249 (Mar. '52). Success of fluoridation installations depends largely on efforts of engineers in city and state health depts., consulting engineering firms, and those employed by equipment manufacturers. Their responsibility involves detn. of how much fluorides to add, which compounds to use, how they should be fed, where they should be applied, how operators would be protected, and how concn. should be controlled. Comparison is made of three most commonly

(Continued on page 42)

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(*Continued from page 40*)

used fluoride compounds (sodium fluoride, sodium silicofluoride, hydrofluosilicic acid) from standpoint of cost, solubility, storage space required, limitations in feeder space, corrosiveness, incrustation in feeders, bulk handling problems, and hazards to operators. Similar comparison made between various types of feeders, different points of application, degree of protection available for water plant operators, and methods for determining fluorides in water. All factors must be carefully weighed to realize this effective public health procedure in each community with greatest safety and economy.—*F. J. Maier.*

A Preliminary Study of the Distribution of Fluorine in Communal Water Supplies in the United States. I. N. Hill, O. E. Jelinek, & J. R. Blayney. J. Dental Research, **28**:398 ('49). A survey has been made of the distr. of fluorine in the water supplies of the U.S. to det. the areas in which fluorine is prevalent, the concentrations in which it occurs, and the number of persons using water in which fluorine occurs naturally. Municipalities where there is a high content of fluorine in the water supply are found in 9 states, the greatest number occurring in Texas, followed by South Dakota. Approximately 5½ million people use water containing 0.5 ppm fluorine and 2 million use water containing 0.9–2.0 ppm fluorine.—*WPA.*

Dental Effects of Exposure to Fluoride-Bearing Dakota Sandstone Waters at Various Ages and for Vari-

(*Continued on page 44*)

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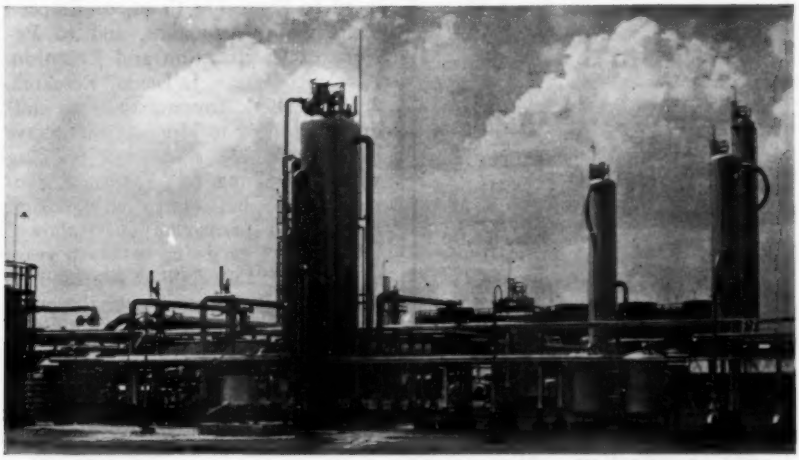

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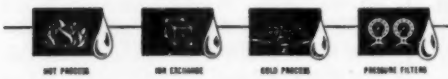

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(*Continued from page 42*)

ous Lengths of Time. II. Patterns of Dental Caries Inhibition as Related to Exposure Span, to Elapsed Time Since Exposure, and to Periods of Calcification and Eruption. A. L. RUSSELL. J. Dental Research, **28**:600 ('49). Investigations on children migrating to Mitchell, S.D., have shown that 133 who used drinking water containing 1.93–2:27 ppm fluorine before but not after the first eruption of permanent teeth showed inhibition of caries up to 14–16 years of age; in 152 children exposed to such water before and after the eruption of permanent teeth, inhibition persisted beyond this age. It is suggested that fluorine is incorporated in tooth enamel and must be renewed periodically or continuously if resistance to caries is to be maintained.—*WPA.*

Connection Between Dental Caries Experience and Water-Borne Fluorides in a Population With Low Caries Incidence. P. ADLER, I. SARKANY, K. TOTH, J. STRAUB, & E. SZEVERENYI. J. Dental Research, **30**: 368 ('51). Eufluorosis is proposed to express the optimal protection against dental caries without production of mottling and with max. satn. of the dental hard-tissues with F. The action of fluorinated water is inhibitive, not merely caries-delaying. The onset of its use must begin within the first 6 yr of life in order to produce appreciable protection against caries in the permanent dentition.—*CA.*

Fluorine Deficiency and Dental Caries. V. DEMOLE. Bul. Schweiz. Akad. Med. Wiss. (Swiss), **6**:121 ('50). Deficiency of fluorine in drinking water in Switzerland is responsible for the high incidence of dental caries among school children. The daily addition of 0.25 mg of sodium fluoride to the diet or addition of fluorine to table salt is recommended.—*WPA.*

(*Continued on page 46*)

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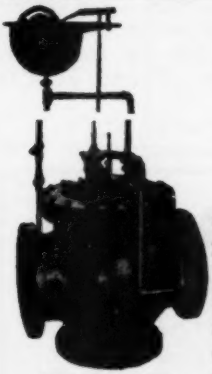

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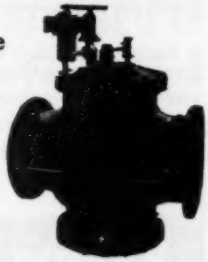

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(*Continued from page 44*)

Water Fluoridation for the Control of Tooth Decay. Wis. Med. J., **49**: 199 ('50). Fluoride is added to the water supplies of sixteen cities in Wisconsin to increase the concentration of fluorine to 1–1.2 ppm. Recent surveys in Sheboygan, where fluoride has been added to water supplies for 4 yr, indicate that substantial reductions in the incidence of tooth decay have already occurred. With adequate diet and dental care and addn. of fluorine to water supplies, it can be expected that the rate of decay will be reduced by 65%.—*WPA.*

Investigations on the Metabolism of Fluoride. II. Fluoride Content of Blood and Urine as a Function of the Fluorine in Drinking Water. F. A. Smith, D. E. Gardner, & H. C. Hodge. J. Dental Research, **29**:595 ('50). A comparison made between 2 pops. whose supplies of drinking water contain concns. of fluoride of 0.06 ppm and 1.36 ppm, resp., showed that with the higher concn. the avg. content of fluoride in urine increased to 1.12 ppm as compared with 0.06 ppm, and that the concentration in the blood increased to 0.40 ppm as compared with 0.014 ppm. It was concluded that the higher concn. of fluoride in drinking water does not result in dangerously high concns. of fluoride in the blood.—*WPA.*

Removal of Fluorides From Water. K. Symon. Paliva a voda (Czech.), **29**:106 ('49). The content of F in H_2O supplies, its effect on health, and its removal by $Ca(OH)_2$, $Al_2(SO_4)_3$, and $Ca_3(PO_4)_2$ are discussed.—*CA.*

BACTERIOLOGY

A Comparison of Enterococci and Esch. coli as Indexes of Water Pollution. William E. Lattanzi & Eric W. Mood. Sew. & Ind. Wastes, **23**: 1154 ('51). Comparison of poln. as detd. by the std. confirmed test for *Esch. coli* and the *Enterococcus* test of Winter and Sandbolzer showed that: (1) a positive correlation exists between the 2 tests; (2) a high *Esch. coli* index will generally predict a correspondingly high *Enterococcus index;* (3) based on the median value of all samples analyzed, the density of *Esch. coli* will approximate 63 times that of *Enterococcus;* (4) more skill is required in performing the *Enterococcus* test; (5) time required for *Enterococcus* test is less than that for *Esch. coli.*—C.A.

Culture Medium for Detecting and Confirming Esch. coli in Ten Hours. George H. Chapman. Am. J. Pub. Health, **41**:1381 ('51). The culture medium is based on an observation that *Esch. coli* does not reduce triphenyltetrazolium chloride (TTC);

(*Continued on page 48*)

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(*Continued from page 46*)

other coliform groups rarely fail to do so. It is made by adding 40 mg of TTC to 1 l of Tergitol-7 agar just before pouring. Inoculation is made on the surface and is spread by means of a glass spreader. If the plates stand several hours before inoculation, 0.1 ml of the sample can be spread over the surface. For larger inocula the plates can be stored in the refrigerator. They lose 0.1 ml of surface moisture per day in closed, not sealed, cans. On this medium, surface colonies of *Esch. coli* produce greenish yellow colonies surrounded by a yellow halo. Other coliforms produce dark red colonies. The differentiation is so sharp that colonies can be observed by a loupe or Magnifocuser in about 6 hr if the medium is warmed prior to inoculation and the plates are placed in single layers in the incubator so that they reach 37 F rapidly. The final reading can be made in 10 hr. *Esch. coli* is not inhibited at all on the medium, in contrast to other coli mediums. Many other coliform organisms are inhibited. Spreaders are never encountered.—*CA.*

Determination of Esch. coli in Water Containing a Bile-Brilliant Green Medium. JANINA SCHMIDT. Roczniki Panstwowego Zakladu Hig., 1:78 (Pol.; Eng. summary 85) ('50). Comparison of the lactose-broth medium (Standard Methods of the Polish Public Health Labs.) with the brilliant green-lactose-bile medium indicates that the first medium is more sensitive for tap-water examn., the second for well and river waters.—*CA.*

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(*Continued on page 50*)

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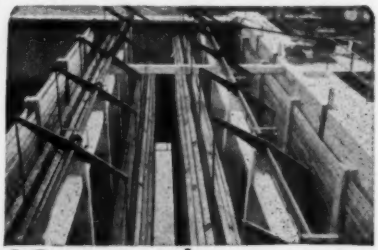

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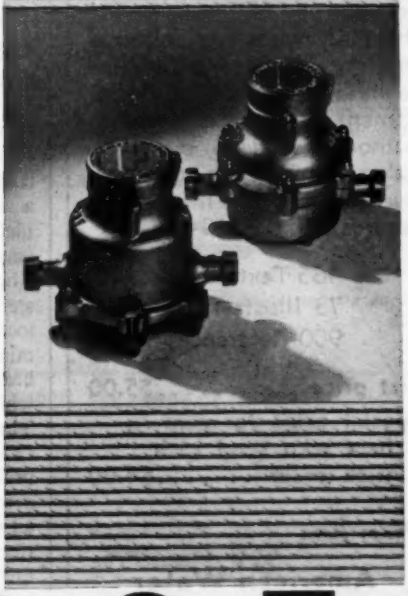

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(Continued from page 48)

for Enterococcus Detection. WEN-LAN LOU WANG & STUART G. DUNLOP. Pub. Health Repts., **66**:1212 ('51). Poor confirmation of presumptive positive counts of fecal streptococci from sewage and irrigation water had been obtained by using the media proposed by Winter and Sandholzer. Studies on blood agar plates, followed by biochem. tests on the organisms isolated, indicated that *Enterococci* were present in at least 95% of the presumptive positive tubes, even though only 66% would confirm in the Winter and Sandholzer confirmation medium. By buffering the Winter and Sandholzer presumptive medium to retard the pH change of the positive and by observing the negative for an addnl. 28 hr, good confirmation and comparable presumptive counts were obtained. 14 references. —*CA.*

Membrane Filter in Sanitary Bacteriology. HAROLD F. CLARK, EDWIN E. GELDREICH, HAROLD L. JETER, & PAUL W. KABLER. Pub. Health Repts., **66**:951 ('51). Equipment and technique are described for employing a membrane filter for the isolation, identification, and counting of organisms present in H_2O, air, and food. The app. is constructed of a stainless-steel funnel connected by a bayonet locking nut to a receptacle which contains a porous plate. The filter membrane is supported on the porous plate, which allows free passage of liquids. The filtrate is collected in a filter flask. Gravity or vacuum filtration may be used. Details for sterilizing the app. are given. The membrane will retain all the bacteria contained in any quantity of H_2O that can be forced through the filter. For colony counts the membrane is removed aseptically to a Petri dish contg. a suitable medium. A no. of different media were studied and

(Continued on page 52)

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(*Continued from page 50*)

the best conditions for obtaining accurate counts are described. Membrane counts on city H_2O and sewage are compared with standard-plate counts. Estns. of coliform organisms and *Salmonella typhosa* are tabulated. The advantages of the method are a reduction in time, labor, space, and requirements for bact. techniques. The ease of transportation permits service to small H_2O plants and rural areas.—*CA.*

Determination of the Germ Count in Drinking Water. Otto Thomann. Mitt. Gebiete Lebensm. Hyg. (Swiss), **42**:106 ('51). In 1249 samples, shown that, generally, the germ count on gelatin nutrients is higher than on agar nutrients. It was concluded that the germs develop more rapidly on gelatin, and that therefore gelatin is preferable as a nutrient for water analyses.—*CA.*

The Role of the Bacteriologist in Evaluating Water Analyses. I. R. Coutris. Bul. Assoc. Diplomes Micro-Biol. Faculte Pharm. Nancy, No. **40**:32 ('50). The fallacy of relying on chem. analyses in the absence of bact. tests is discussed. A deep well water, low in bacteria, may be high in NH_4 owing to passage through strata contg. fossils. High Cl does not always indicate contamn. Two chem. analyses of the same water by different labs. are tabulated. An incomplete chem. analysis by one lab. aroused doubt, owing to high Cl and NO_3. More complete analyses by a second lab. indicated that the water was of good sanitary quality, as no *Esch. coli* or *Clostridium perfringens* could be found. **II.** *Ibid.*, No. **41**:3. History of the Paris water supply, collection of bacteriol. samples, and use of different culture media are discussed. **III.** *Ibid.*, No. **42**:8 ('51). Significance of *Esch. coli* and *C. perfringens* is discussed, also methods of concg. bacteria by pptn. with $Al(OH)_3$. —*CA.*

BOILERS AND FEED-WATER

Electrical Treatment of Boiler Feedwater. T. F. Hurley, H. Ingleson, W. J. Sparkes, & R. Wilkinson. J. Inst. Wtr. Engrs. (Br.), **5**:686 (Nov. '51). Many reports of successful use of electrical devices for scale prevention have appeared. Such extravagant claims have been made by advocates of some devices that there has been tendency to dismiss as unworthy of serious consideration all favorable statements concerning electrical treatment of boiler feedwater. Fuel Research Station and Water Pollutional Research Laboratories of Dept. of Scientific & Industrial Research were

(*Continued on page 54*)

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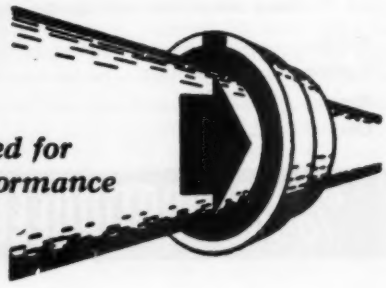

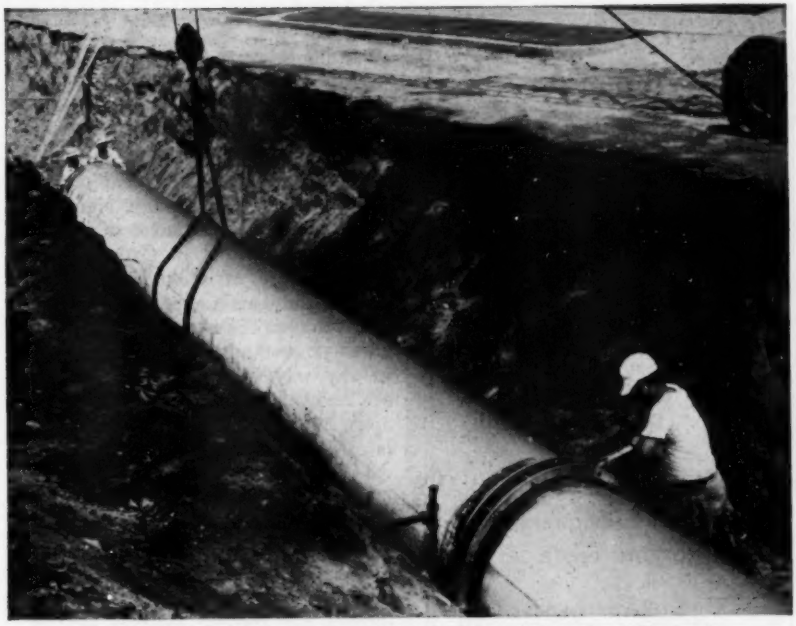

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(*Continued from page 52*)

accordingly asked by Ministry of Works and Air Ministry to investigate some processes. Two proprietary units were used in first test. As result of Group 1 tests, general conclusion was that electrical treatment of feedwater did not have any significant effect on ease of removal of deposits in boiler. Results in Group 2 tests showed large variations in nature of deposits in same expt. and in same boiler under different expts. Differences do not appear to be associated in any way with electrical treatment of feedwater and they are equally apparent whether electrical treatment is used or not.—*H. E. Babbitt.*

Chemical Feeding—Direct to Boilers. SHEPPARD T. POWELL. Power, **95**:7:76 ('51). The importance of proper feeding of chemicals to the boiler is stressed. Several types of feeders and feeding systems are pictured and described. The handling is especially important.—*CA.*

How to Protect Stand-by Boilers. R. B. CONLON. Paper Ind., **33**:799 ('51). "Dry storage" of idle boilers may involve the introduction of CaO, SiO_2 gel, and Al_2O_3. In "wet storage," mixts. Na_2SO_3 and aq. NaOH, or aq. solns. of $Na_2Cr_2O_7$ (at pH 7.5–9.5) can be used. Protective paints and coatings are also mentioned, but these cannot be relied on solely.—*CA.*

The Preparation of Distilled Water as Boiler Feedwater. C. H. ALLEN. Chem. & Ind. (Br.), **1951**:772 ('51). Make-up for two 650-psi Stirling boilers each haxing a max. continuous rating of 125,000 lb of steam per hr is secured by the use of evaporators. The use of process condensate was considered undesirable in view of occasional traces of sugar. Water from the Metropolitan Water Board is heated to 80 F by means of waste heat

(*Continued on page 56*)

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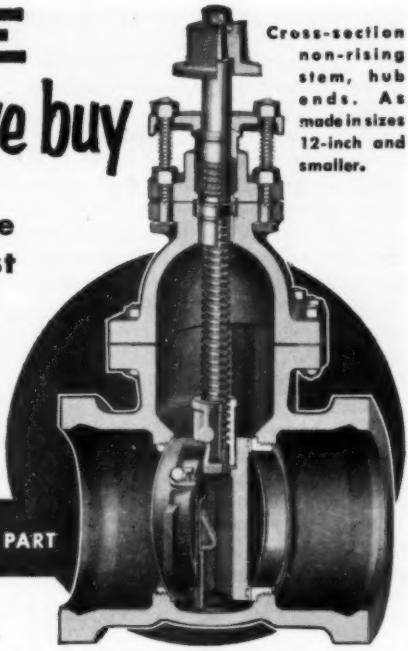

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(*Continued from page 54*)

and then softened by the lime-soda–sodium aluminate process, the hardness being reduced to 10 ppm. After settling, the water is clarified in filter presses and further heated to 90–95 F and deaerated by means of flash steam from various plant sources. Pptn. of the small residual hardness on the jets and pipes of the deaerator is prevented by the addition of 4 ppm of a tannin-phosphate mixt. The remaining O concn. in the water is scavenged by the addn. of Na_2SO_3. The sulfate in the raw water and from the sulfite is sufficient to maintain the desired sulfate to hydroxide ratio. A further addn. of sufficient Na hexametaphosphate with a small amt. of tannin is made to maintain a reserve of 80 ppm PO_4 in the evaporator water to ppt. the hardness salts as a sludge in the evaporators. Quadruple effect evaporators are used, the calandria of the first effect being fed with steam at 250 psi from the boilers. The softened feedwater is fed in parallel to the 4 evaporators; the condensed water from the calandria of each still passes through a heat exchanger and imparts some of its sensible heat to the softened water entering the body of the still. Excessive corrosion due to CO_2 was noted in these heat exchangers which lowered the pH of the distillate to 6.5. This trouble was cured by spraying 1% of boiler water from the high pressure boilers into each calandria, which raised the pH of the distillate to 8.7.—*CA.*

Scale Control in Sea-Water Distillation Equipment. W. F. LANGELIER, D. H. CALDWELL, W. B. LAWRENCE, & C. H. SPAULDING. Ind. Eng. Chem.,

(*Continued on page 58*)

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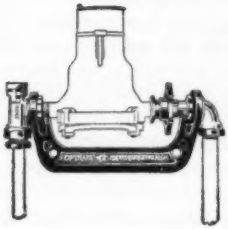

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(*Continued from page 56*)

42:126 ('50). Compression evaporators used in the distillation of sea water develop large quantities of scale composed chiefly of either $CaCO_3$ or $Mg(OH)_2$. Equilibrium data were determined for these salts in concd. sea water at 212 F and it was found that brine will remain supersaturated with $CaCO_3$ and $Mg(OH)_2$ for longer periods than the usual periods of detention in evaporators. A contact-stabilization method of controlling scale was developed. The brine from the evaporator flows through a compartment containing a layer of limestone granules or other suitable material on which the excess salt is deposited. The brine then flows back into the evaporator. The authors obtained good results with rates of circulation of from 6 to 10 times the rate of entry of raw water. Tests have shown that this method reduces the amount of scale in the evaporator to less than 10% of the normal amount formed. —*WPA.*

Evaporator Survey Improves Vapor Purity. R. S. CAUSEY. Southern Power & Ind., **69**:5:98 ('51). City water, with a dissolved solids content of approx. 35 ppm, of which about 35% was dissolved Si, was used as evaporator make-up, but difficulty was encountered in securing condensate of adequate purity for boiler feed. The coil steam for each evaporator was supplied from the first-stage extraction of its respective turbine. Tests indicated that any increase or decrease in turbine load rating affects the quality of the evaporator, and that best results were obtained with the evaporator and turbine at full rating. When possible, the evaporator rate should be free to correspond to the load on the turbine, provided the turbine is at half- to full-rated load and that the load is fairly constant. At min. rating or when load is rapidly falling, the evaporator should not be operated. Excessive O concn. in the condensate when the evaporator was started up was reduced by securing a better steam supply for the feed preheater and by moving the vent from the side of the evaporator shell to the vapor offtake. These precautions have improved the condensate quality.—*CA.*

CORROSION AND CORROSION CONTROL

Problems of Preventing Corrosion in Water Works. ERICH GEBIGKE. Bergbau u. Energiewirt, **3**:164 ('50). The advisability and economy of painting are discussed. The following groups of paints are recommended: (1) chlorinated rubber paints; (2) bituminous and tar paint, which, according to consistency, are used as hot or cold paints; (3) oil and varnish paints; and (4) synthetic resin paints. Paints in group 1 are almost always superior, and are used successfully as underwater protection against corrosion. They are available in light colors and they dry perfectly in a few hours. The evaluation and handling of the other paints are also described.—*CA.*

Protecting Waterworks Steel Structures Cathodically. FRANK P. MACDONALD. Corrosion, **7**:6:1 ('51). Tests of various types of paints applied to Dorr clarifier and flocculator basin steel indicated that none of the coatings gave complete protection; the most satisfactory coating appeared to be a coal-tar enamel applied hot to steel cleaned by sandblasting. The cost of sandblasting and applying this coating, however, was estd. at $45,000 and the units have to be taken out of operation. Cathodic protection was applied with an external rectifier for each clarifier and flocculator basin. These rectifiers were operated at 4 v and 12 amp with water temp. at 44 F. Structure-to-water potentials at various points on the struc-

(*Continued on page 60*)

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(*Continued from page 58*)

ture varied from — 770 to — 1020 mv, and complete protection of the steel was observed after 1 yr, except for the remotely located expansion plates in each basin. The latter freely corroding steel had a potential to water of — 410 mv. Electrodes were of 17ST4 Al bar stock, with an estd. life of 3 yr. Cost of installation was about half the painting cost, and operating cost has been limited to capital charges plus current for the rectifier.—*CA.*

Investigations on Underground Corrosion. K. R. Butlin, W. H. J. Vernon, & L. C. Whiskin. Wtr. & Wtr. Eng. (Br.), **56**:15 (Jan.'52). It was shown in 1934 that sulfate-reducing bacteria may play important part in corrosion of underground iron structures. Expts. carried out by Bunker confirmed microbiological mechanism. Organisms, by setting up "hydrogen acceptor" system, afforded mechanism for disposal of cathodic hydrogen. Much positive evidence in support of microbiological view has been obtained from observations in field. Pure cultures are able to grow and reduce sulfates anaerobically in inorganic medium when gaseous hydrogen is present. Thermophilic strains can be isolated from most soils. Bacteria are resistant to ordinary antiseptics such as chlorine, lysol, and phenol. Ferrous ions exert considerable adverse effect on some inhibitors. Field investigations have been carried out to collect evidence on extent and types of corrosion of ferrous pipes in wide variety of soils; to make close examination of corroding pipes in natural environment; and to conduct expts. on protection of pipes. Evidence shows majority of corrosion troubles occurred in clay soils and most are associated with activities of sulfate-reducing bacteria. Second most common type of corrosion is caused by ashes, clinker, and make-up ground. Tour of inspection of South Essex Area led to

(*Continued on page 62*)

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(*Continued from page 60*)

several conclusions: [1] sulfate-reducing bacteria were present in all soils; [2] wet conditions were common to all areas in which leaks resulting from pitting were prevalent; [3] bitumen-impregnated hessian wrappings used for protecting steel pipes were mostly rotten and brittle after 10 to 20 yr of service; [4] leakages resulting from corrosion in chalk are few in comparison with those in clay; [5] cast-iron gas pipes buried in clay are less subject to failure than are steel pipes; [6] failures of cast-iron pipes conveying gas in clay soils are much fewer than similar pipes conveying water. Lengths of 4-in., metal-spun iron pipes were buried in Sept. '46 with various methods of protection. Pipes were examined in Aug. '49. Appearance of pipes is indication of danger of laying inadequately protected ferrous pipes in wet clay soil, and suggests that adequate bitumen coatings, concrete surrounds, and gravel surrounds provide good protection. At Chigwell three specimens of each kind of various types of pipes were buried between March and June '49. Test pieces included, besides iron, copper, steel, lead, cement, asbestos, alkalethene (plastic), and other pipes. Other specimens were buried in Mar. '50, the first series to be examd. in '52.—*H. E. Babbitt.*

Cathodic Protection of Buried Metal Structures. R. DE BROUWER. Wtr. & Wtr. Eng. (Br.), **56**:97 (Mar. '52). Cathodic protection of underground pipelines against corrosion was first mentioned in 1930, approx., although it had been successfully applied to pipelines under the name "drainage," and to such steel structures as ships' hulls under the name "Cumberland" method. Pourbaix has developed new technique of graphical representation of chemical and electrochemical equilibria. Relationships connecting pH and electrode potential values can be established from published thermodynamic data by plotting, as abscissa, pH of soln. and, as ordinates, equilibrium thermodynamic potential of each of oxidation and reduction reactions that can occur in presence of soln. Following relationships can be established mathematically:

$$I = \frac{I_D}{\sinh\sqrt{\frac{r}{t}}\,l}\sinh\sqrt{\frac{r}{t}}\,(l-x) \quad \ldots(1)$$

$$E = \frac{E_D}{\cosh\sqrt{\frac{r}{t}}\,l}\cosh\sqrt{\frac{r}{t}}\,(l-x) \quad \ldots(2)$$

Equiv. resistance of cathode is given by:

$$R_e = \frac{E_D}{I_D}\sqrt{\frac{r}{t}}\,\frac{1}{\tanh\sqrt{\frac{r}{t}}\,l} \quad \ldots\ldots\ldots(3)$$

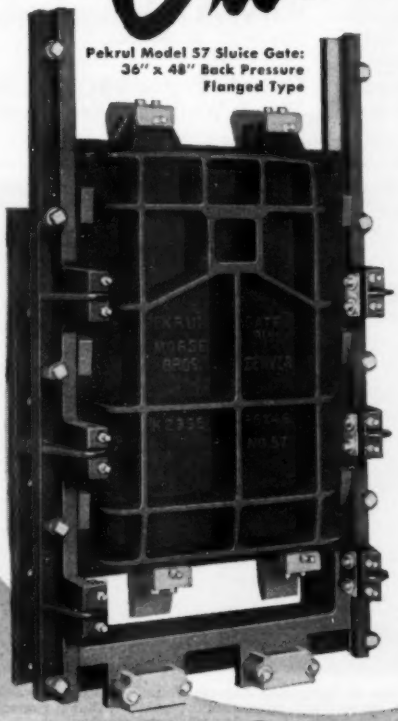
At end of protected section, $I_l = 0$, and therefore:

$$E_l = \frac{E_D}{\cosh\sqrt{\frac{r}{t}}\,l} \text{ or } \frac{E_d}{E_l} = \cosh\sqrt{\frac{r}{t}}\,l \quad \ldots(4)$$

where I_D = current flowing from half pipeline of length $2l$; I = current flowing in pipeline at distance x from point of drainage; E_D = potential of pipeline at point of drainage with respect to point in soil outside field of anode or cathode; E = potential of pipeline at distance x from point of drainage; r = longitudinal resistance of pipeline in ohms/meter-run; $t = \frac{1}{c}$ = resistance to earth of pipeline in ohms/meter-run; and R_e = equivalent resistance of half of pipeline. If potentials resulting from return currents of electrified traction lines are unimportant, frequently cathodic-protection installations correspond exactly with theoretical conditions given

(*Continued on page 64*)

Pekrul Gates



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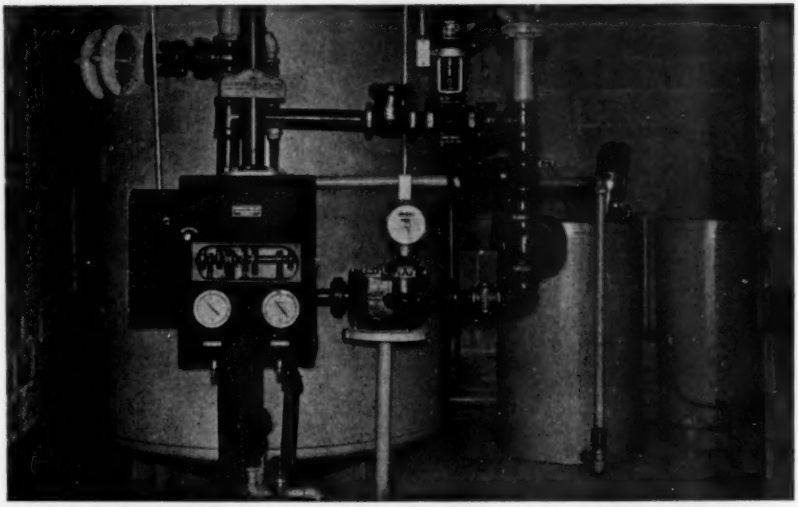
(*Continued from page 62*)

above. Because electric traction rails constitute ideal and gratuituous anodic circuit, and also often furnish necessary polarization currents, electric drainage is most efficient and cheapest process of cathodic protection. Drainage apparatus must be of large dimensions capable of resisting inverse potentials of several tens of volts, while at same time allowing flow of several hundreds of amperes without producing large potential drops. Cathodic polarization caused by stray currents may be neutralized by draining these currents through one, or usually, several connections to return circuits of electric traction lines, a process known as polarized drainage. If mean natural drainage current is insufficient to insure required min. protection potential, it is necessary to apply external emf, a process known as forced drainage. Installation of equipment for cathodic protection requires perfect electrical continuity of structures to be protected, and insulation from other structures that should not participate in protection. Both theory and expt. show that buried metallic structures are immune from corrosion when sufficiently electronegative with respect to their surroundings. Tests have been established to determine best method of cathodic protection in particular installation. Good quality of protective coating facilitates cathodic protection and, in turn, cathodic protection preserves efficiency of coating that would otherwise deteriorate rapidly.—*H. E. Babbitt.*

Cathodic Protection. K. A. SPENCER. Wtr. & Wtr. Eng. (Br.), **56**:62 (Feb.

(*Continued on page 66*)



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CALMET WATER METERS

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(*Continued from page 64*)

'52). Buried pipeline runs through many different types of soil, and changes in concn. of soluble salts from point to point result in concentration-cell effects. In desert areas, such as those experienced in Middle East, concentration-cell effect represents principal cause of pipeline corrosion. Electrolytic-cell corrosion may result from variation in potential of buried pipeline relative to soil, caused by stray direct currents. Galvanic-cell corrosion may occur when dissimilar metals are in contact. In waterlogged anaerobic conditions, sulfate-reducing bacteria have ability to reduce sulfates to sulfides and of removing hydrogen from cathodic surfaces, and thus allow current to flow. Corrosion of metal in electrolytes is always associated with positive electrical current flow from metal to electrolyte at point of corrosion. If sufficient electrical current is flowing uniformly into metal surface from electrolyte, metal ions cannot travel from metal surface to electrolyte. Before applying cathodic protection, survey of ground should be made. The soil type should be classified to ascertain concn. of soluble salts. Sampling is essential when checking for presence of sulfate-reducing bacteria. Simple pipe-to-soil potential may be measured by making electrical contact with pipe and taking lead to negative terminal of potentiometer or high internal resistance, direct-reading voltmeter. Second lead goes to Cu—$CuSO_4$ half-cell which is placed in close contact with soil as near metal structure as is conveniently possible. Rate of corrosion at anodic area is directly proportional to current flowing from it to soil. Condition of any protective insulating coating is of interest as current required for cathodic protection is direct function of amount of bare metal exposed. Even newly coated pipe almost invariably contains minute holes where water can enter and corrosion can occur. Frequently either power-supplied or sacrificial-anode system may be used. The latter is limited when soil resistivities are high and when large uncoated areas call for heavy current flow. Sacrificial anodes are blocks of magnesium, aluminum, or zinc, and are electrically connected to structure. When sacrificial anodes are unsuitable or when protection over a large area is required, power-supplied scrap metal or carbon groundbed is frequently preferable. Most convenient method of supplying positive direct current to groundbed is from d-c power supply. Economic advantages of properly applied cathodic protection are well-known. Many highly successful installations now exist.—*H. E. Babbitt.*

Water Treatment for Corrosion Control. C. W. DRANE. Wtr. & Wtr. Eng. (Br.), **56**:52 (Feb. '52). Corrosion troubles have been overcome to large extent by use of resistant materials. When nonresistant materials have been installed, it is often too expensive to replace them, and, sometimes, pipes are inaccessible. Corrosion control of water system usually implies addn. of chemicals. First group of chemical inhibitors consists of "reactivators" which remove from water constituent on which corrosion depends—usually oxygen. Second group consists of "inhibitors" which form and maintain protective film on metal surface. This paper is mainly concerned with inhibitors, particularly metaphosphates. Of reagents available for chemical deoxygenation, most common is sodium sulfite. Treatment is expensive and careful control is necessary for potable waters. Deaeration in heated plants is more effective but is suitable only in high-pressure, steam-boiler feed. Other methods of chemical deoxygenation, such as con-

(*Continued on page 68*)

a report by ROBERTS FILTER

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(*Continued from page 66*)

tact with iron turnings, require special conditions of temp. and pH which render them unsuitable for general use. Any chemical added to domestic water should not be harmful to health, even if accidently overdosed; film should be of reasonably uniform thickness and should not impede flow or rate of heat transfer; and there should be no acceleration of corrosion at discontinuities in film. Many waters form deposits of calcium carbonate on metal surfaces. To encourage this deposition by addn. of alkali is to modify equilibrium, a difficult method for soft waters as pH value would be raised too high for most industrial and domestic purposes, or substantial increase in hardness may be obtained. It is difficult also to get uniformly thick scale. Satisfactory conditions for one temp. may be unsatisfactory at another temp. Raising pH value of water without reference to calcium carbonate equilibrium is liable to produce unfortunate results. Above pH 9, approximately, there appears to be change in nature of products of corrosion formed, with or without chemical inhibitors, and, except in presence of substantial amount of chloride ion, formation of closely adherent protective film seems to occur. In "dangerous" pH range (7.5 to 9.0), products of corrosion of iron are voluminous compared with iron from which they are formed. Such accumulations are liable to reduce rate of flow to serious extent. Other alkaline inhibitors proposed are silicates of soda. For effective action they require presence of calcium ion, so cannot be used with distilled water. They have marked success in treating small supplies for

(*Continued on page 70*)

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(*Continued from page 68*)

prevention of plumbo solvency. They are, in general, unsuitable for treatment of water subsequently used for steam boiler feed. Two other inhibitors valuable under special circumstances, but unsuitable for domestic and many industrial purposes, are potassium chromate and soluble zinc salts. Orthophosphates have been employed in exptl. work but are objectionable in practice owing to marked accelerated corrosion which occurs with low concentrations. Sodium nitrite is anodic inhibitor used in pipelines conveying oil contamd. with water. Sodium benzoate has been used to impregnate materials which cause corrosion in contact with metal. Inhibitors used with marked success are glassy phosphates of sodium or sodium and calcium, typified by Calgon and Micromet, respectively. Water treatment with metaphosphates, known as "threshold treatment," has found wide application in prevention of calcium carbonate deposit. Calgon is usually applied as dilute solution, but proportional rate of application is too expensive in small systems. Micromet, slowly soluble metaphosphate glass of sodium and calcium, is of particular value in such systems. Metaphosphate forms protective film of some kind on metal surface and this is slowly removed by flow of water after its transformation to orthophosphate. It is customary to classify corrosion inhibitors as "anodic" or "cathodic" according to which electrode is covered. Anodic inhibitors are regarded as "dangerous" because, in less than minimal concns., corrosion may be accelerated in dangerous areas. Cathodic inhibitors, such as zinc, cal-

(*Continued on page 72*)

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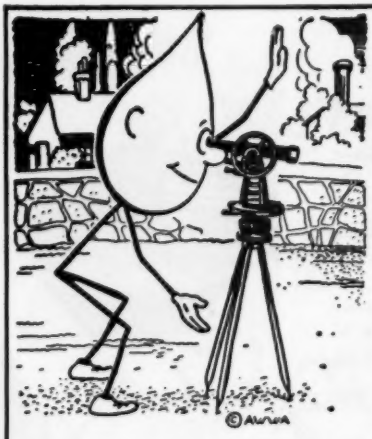
(*Continued from page 70*)

cium, and magnesium salts are safe when used in lower than prescribed concns., but they are frequently less effective than the anodic group. Important aspect of corrosion control using metaphosphate is starting treatment by using higher concn. than will be required for continuous treatment, and thus building up protective film quickly. Doses required will depend on number of factors, but final requirements will usually be between 1 and 2 ppm for main supply system and 10 ppm for make-up to circulating cooling circuit. To check water to determine corrosion inhibition properties, a satisfactory test is that for residual phosphates. To assess success of inhibition, inspection of typical parts of plant is usually most satisfactory procedure. Method of control applied to hard waters softened by base-exchange method is similar to that used for naturally soft waters. Use of inhibitors to prevent corrosion of nonferrous metals is rarely considered necessary. Any inhibitor added to control corrosion of iron should not have deleterious effect on lead or copper, as these are often found in water systems. Some rusty deposits in pipelines are due to "iron bacteria" and not to corrosion. Iron bacteria are not corrosive agents but some waters contain another type of organism known as sulfate-reducing bacteria which are active agents of corrosion. Attack is more frequently found on exterior surface of mains. Protective treatment against interior attack consists of filtration and chlorination.—*H. E. Babbitt.*

Protection of Underground Pipes Against Corrosion. L. VANDERBORCHT. Water (Neth.), 35:203

(*Continued on page 74*)



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1"	1.433	1.070	120	.285	300' "
1¼"	1.850	1.380	120	.477	300' "
1½"	2.260	1.610	120	.790	250' "
2"	3.000	2.070	120	1.88	200' "
2"	2.495	2.070	75	.620	200' "
2½"	2.930	2.470	75	.820	150' "
3"	3.670	3.070	75	1.280	100' "
4"	4.820	4.030	75	2.200	25' straight
6"	7.260	6.070	75	5.000	25' "

Now... CARLON "WS" corrosionproof plastic pipe offers new advantages for municipal water system service connections. It is easier to handle, faster to install and lasts longer than any metallic pipe.

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(*Continued from page 72*)

(Sept. '51). It is difficult to determine current intensity required when cathodic protection is employed. Results obtained show the following, where i = current intensity per sq m of pipe, s/S = relation between total anode surface and pipe surface, and d = current density per sq m surface of anodes.

ANODES	*i* ma/sq m	*s/S* per cent	*d* ma/sq m
Old distribution system, diam. of main line—60 mm. Two leaks	6.5	20	27
Supply main—diam. 300 mm, corrosion by electrolysis	0.8	1.5	65
Old distribution system—diam. 60 mm	5	26	18
MAGNESIUM ANODES			
Old distribution system—diam. 60 mm	2.2	5.5	40
New lines—diam. 60 and 80 mm	0.5	2	26
Siphon, 800 mm, no corrosion	0.5	0.3	117
Gas distribution line after 1 yr	0.8	2.2	33

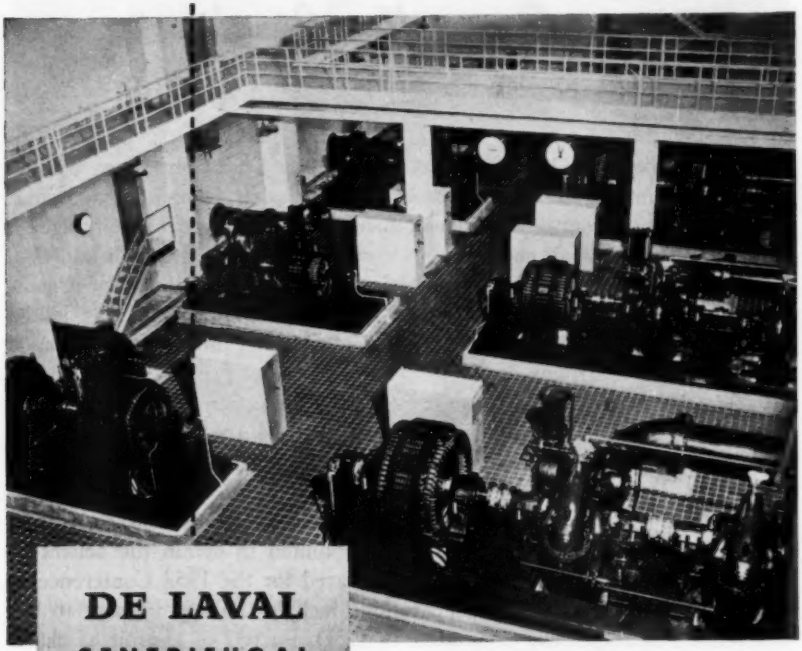
Results indicate that required current intensity is 0.3 to 0.5 ma/sq m for steel pipe protected from beginning, 0.5 to 2 ma/sq m for pipe after 2 yr and subjected to certain tension, and 2 to 6.5 ma/sq m for corroded pipe.—*W. Rudolfs.*

OTHER ARTICLES NOTED

Recent articles of interest, appearing in American periodicals, are listed below.

The Membrane Filter in Water Quality Tests. HAROLD F. CLARK & PAUL W. KABLER. Am. J. Pub. Health, **42**: 385 (Apr. '52). *Discussion. Ibid.*, 42:389 (Apr. '52). ALEXANDER GOETZ.

Delivering 172 mgd more for Cleveland



These new De Laval centrifugal pumps in the Nottingham filtration plant help deliver an additional 172,000,000 gallons of filtered water daily to Cleveland's growing population. Today 80% of America's largest cities depend upon efficient De Laval centrifugal pumps. They are available in capacities ranging from less than one million gallons per day to more than 100 million gallons per day.

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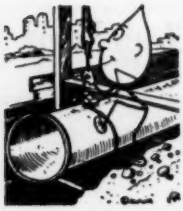

Committee Pipeline

● **Appointments:** Those made at the Kansas City Conference will do much to maintain the present pace of Association committee activities. Automatically, of course, President Capen and Vice-President Cunningham become members of all committees by virtue of their office. In addition, however, a number of other changes have been made at all levels of organization. H. F. O'Brien, president of A. P. Smith Mfg. Co., has joined the Executive Committee of the Board of Directors, and President Capen has become its chairman.

The Program Committee appointed by Publication Committee Chairman Richard Hazen consists of the chairmen of the Association's four divisions: Morrison B. Cunningham for Management, Dale L. Maffitt for Resources, Ray L. Derby for Purification, and E. A. Schmitt for Transmission and Distribution. In addition, Louis E. Ayres and Robert L. McNamee of Ann Arbor, Mich., were appointed to obtain the benefit of their advice on regional papers to be prepared for the 1953 Conference in Grand Rapids. Other 1953 preparations include the appointment to the Convention Management Committee of E. D. Barrett of Detroit as chairman, T. L. Vander Velde of Lansing, and William Leslie Harris of Grand Rapids.

● **Backflow preventers**—The Executive Committee of the Board of Directors has agreed to establish, in cooperation with the Conference of State Sanitary Engineers, a committee to study backflow preventers. Representatives of the state engineers, the fire underwriters, the manufacturers, and the users will constitute the committee. The wide divergence of opinion on the use and quality of this type of equipment was cited as justifying the need for a committee investigation.

● **G–16**—The Task Group on Uniformity of Grading, Registration, and Short Courses is now reviewing the questionnaires returned to it. Fred Merryfield, A. P. Black, and Edward R. Stapley are working on the material on water works short courses. Both curriculum and frequency of instruction are being studied. Licensing and operator certification are being studied by R. J. Faust, and Edward S. Hopkins is reviewing returned questionnaires dealing with courses other than the standard, practical short

(*Continued on page 78*)

. . . MEN AT WORK!

Beneath the surface of this undisturbed street in Washington, D. C. men are at work . . . reconditioning water pipelines with the Centriline process. Above ground, traffic flows smoothly . . . unobstructed by the usual men, machinery and excavations.

Because the Centriline process centrifugally applies cement-mortar lining to pipes in place, excavation time, overall costs and interruption to street traffic are kept at an absolute minimum. Couple these advantages with the fact that Centrilining permanently prevents corrosion and tuberculation, increases carrying capacity, reduces pumping costs, gives new pipe service at a fraction of the cost of new pipes, and you have the reason why more and more city engineers and officials are specifying Centriline for their pipeline projects.

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(*Continued from page 76*)

course. The study, which the task group hopes to complete in time to report to the AWWA board next January, should indicate the desirability of expanding the number and content of the courses given. In addition, it may give direction to future in-service training and licensing and certification procedures.

(*Continued from page 20*)

In Rome they're still doing as the Romans did—and in the rest of Italy too—that is going to the hills for pure water rather than purifying that on hand. But there is a will—owned by one Dr. Ing. Mario Braschi of the Italian Ministry of Public Works—and even though the way is bound to be long and devious, he's already well on it. First step was an article in the January 1951 issue of the JOURNAL on the Brantford, Ont., purification plant; second was correspondence with its author, Don Williams, developing more information about both Brantford and American practice generally; and third is to be attendance at next year's Grand Rapids Conference. How right can your direction be?

Wilbur C. Milhous, general accountant of the Indianapolis Water Co., has been appointed purchasing agent. His connection with the utility began in 1923, and he has been doing bookkeeping and accounting work for the company ever since. He succeeds the late Gordon Barker, who died unexpectedly while on his way to the Kansas City Conference.

David B. Lee, director of the Bureau of Sanitary Eng. of the Florida Board of Health, was elected president of the Florida Engineering Society at the organization's annual meeting, held in Daytona Beach April 24–26.

A long-range weather forecasting service is being offered by Blewett Weather Service, 919 E. California St., Pasadena 5, Calif. In addition to a detailed, 30-day, map-type forecast, predictions up to six months in advance, in 10-day periods, are offered.

(*Continued on page 80*)

just a reminder that -

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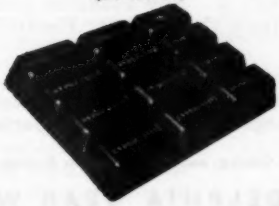

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(*Continued from page 78*)

A McIlroy Pipeline-Network Analyzer has been installed at the Midwest Research Institute, where it will be used to solve distribution system flow problems for water, oil, gas, and even steam and refrigerating air. The analyzer is the third constructed by the Standard Electric Time Co., Springfield 2, Mass., according to the method invented by Malcolm S. McIlroy (*see* April 1950 JOURNAL, p. 347). The other two have been installed at Washington State College and Cornell University. By using special nonlinear resistors in an electrical circuit, the analyzer produces answers to flow problems in a fraction of the time required for "trial and error" computations.

Shocked we were to notice that the dentist member of the North Carolina State Board of Health was one A. C. Current from, actually, Gastonia. Just the thought of his professional chair sent us immediately to the names of three M.D. members listed above him on the Board's letterhead—Hunt, Large, Bender!

Karl R. Kennison, formerly chief engineer of the Metropolitan Dist. Water Supply Commission, serving the Boston area, has become chief engineer for the New York Board of Water Supply, agency in charge of developing new sources for the New York City area.

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Now place yourself in the position of an engineer reviewing this job years later. The "Century" Asbestos-Cement Pipe still has the same carrying capacity—because it never tuberculates, rusts or corrodes, its smooth inner surface is permanent. Outwardly it is intact due to its high resistance to the destructive effects of soils. The "Century" Simplex Couplings, though still flexible have become a permanent part of the line. In fact "Century" Asbestos-Cement Pipe actually increases in strength over the years. Therefore if occasion arises it can be re-used at its original classification.

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The Reading Meter

(*Continued from page 22*)

Water Engineer's Handbook 1952. *The Colliery Guardian Co., Ltd., 30 Furnival St., Holborn, London, E.C. 4, England (1952) 314 pp.; 18s 7d [approximately $2.60 U.S.]*

Compiled by the editorial staff of *Water & Water Engineering,* this handbook contains a directory of water supplies in the British Isles, with information for each on the chief officers, sources of supply, character of water (including its hardness), treatment, and rates charged. A table furnishes data on population, consumption, storage capacity, and length of mains. Other relevant information is provided on British standards that are applicable, and governmental agencies, and a section contains much mathematical and engineering information.

Southwest-Lower Mississippi Drainage Basins: *Summary report on water pollution. Water Pollution Series, No. 16; Public Health Service Pub. 160; Div. of Water Pollution Control, Public Health Service, Washington, D.C. (1951) 136 pp.; paperbound*

The watershed considered in this report is that drained by the Arkansas, White, and Red Rivers together with the lower Mississippi, from Cairo, Ill., to the Gulf of Mexico. It includes the states of Oklahoma and Arkansas, most of Louisiana, about half of Mississippi and Kansas, and portions of six other states, and houses an estimated 1950 population of 11,500,000. Ground water is as extensively used as surface water for public supplies in this region, and by four times as many utilities. To reduce the damage from pollution of all sorts, it is recommended that 581 sewage and industrial waste treatment projects be built—517 for municipalities and 64 for industries. For the municipalities, the specific recommendations are for 132 new plants, enlargements or additions for 251 existing plants, and replacement of 134 others.

The report is the last in the series authorized by the Water Pollution Control Act of 1948.

The Solvay Sales Div. has been consolidated with the Solvay Process Div., and now functions under the latter name. Both organizations are divisions of Allied Chemical & Dye Corp.

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for tapping water mains and inserting corporation stops 1" to 2" inclusive, under pressure. Will make dry taps up to 4". Can be equipped for use on pressures up to 200 lbs. p.s.i.

"B" WATER TAPPING MACHINE

for tapping water mains and inserting corporation stops ½" to 1" inclusive, under pressure. Will make dry taps only from ⅜" to 2½". Can be equipped for use on pressures up to 400 lbs. p.s.i.

ADAPTABLE describes Mueller Water Tapping Machines! *Adaptable* for tapping mains under pressure or dry. *Adaptable* for tapping and inserting corporation stops in cast iron pipe, cement-lined cast iron pipe, asbestos-cement pipe, thin-walled steel pipe. *Adaptable* for tapping Mueller or Iron Pipe thread holes and inserting stops in the full range of sizes from ½" to 2". *Adaptable* for working on mains ranging from 2" to 48". For more information write for Catalog H or see your Mueller representative.

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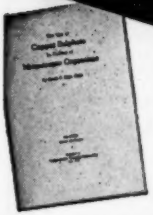
to WATER WORKS and SEWAGE MEN

HOW TO CONTROL ALGAE



"The use of Copper Sulphate in Control of Microscopic Organisms" is an authoritative work on control of micro-organisms and elimination of tastes and odors. Describes methods of controlling various forms of microscopic life commonly encountered in water supply systems. Contains descriptive material, plus 48 photo-micrograph studies of organisms discussed.

ROOT AND FUNGUS CONTROL

"Copper Sulphate for Root and Fungus Control in Sanitary Sewers and Storm Drains," by John W. Hood, contains information published for the first time. This material includes actual methods for control and operating procedure. Here's the book that is a "must" for all sewage men.

GET EITHER OR BOTH OF THESE BOOKLETS ABSOLUTELY FREE—
These two valuable booklets, so important to all water works and sewage men, are yours *without obligation*. For your copy of either one or both books, write on your company letterhead to Dept. JW-752.

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Service Lines

Salinity indicator systems which may be used for chlorination control as well as boiler, condenser, or other water monitoring tasks are described in a booklet distributed by Pilot Marine Corp., 39 Broadway, New York 6, N.Y.

Dehumidifiers for industrial applications are described in a catalog-folder distributed by Abbeon Supply Co., 179–15 Jamaica Ave., Jamaica, N.Y. In addition to a heavy duty unit that services approximately 13,500 cu ft, the company furnishes a variety of instruments for measuring relative humidity.

"Engineering Careers in the Veterans Administration"—which runs 44 water supply and treatment systems on government reservations—are promoted by Pamphlet 5–15, available from the Veterans Administration, Washington 25, D.C.

Coal-tar base enamels for protective coating of pipelines are described in a 24-page booklet available from Reilly Tar & Chemical Corp., Indianapolis, Ind. Information on a compound for protection of mechanical couplings is included, as well as a table of quantities required.

Turbine vane pumps for hot, cold, clear or vaporous liquids are described in a bulletin distributed by Peerless Pump Div., Food Machinery & Chemical Corp., 310 West Ave. 26, Los Angeles 31, Calif.

NO NEED to buy bigger and bigger pumps...

when you protect pipe lines with BITUMASTIC® 70-B ENAMEL

PIPE LINES DON'T "SHRINK" when you coat interior surfaces with a spun lining of Bitumastic 70-B Enamel—because this durable enamel *prevents* rust, corrosion, incrustation and tuberculation.

When the inside diameter of your pipe line *stays* the same, there's no decrease in line capacity. So it isn't necessary, even after decades of service, to replace pumps with bigger ones that cost more to buy and operate.

Besides saving money on pumping costs, Bitumastic 70-B Enamel also effects economies when you purchase pipe for your water lines. That's because you don't have to specify *over-sized* pipe in order to allow for future "shrinkage." You select pipe solely on the basis of desired capacity.

Bitumastic 70-B Enamel is also used to protect exterior surfaces of pipe lines. It prevents pitting and leakage caused by soil corrosion, thus cutting maintenance and replacement costs.

Protect your community's steel pipe lines, inside and out, with Bitumastic 70-B Enamel. Our representative will gladly assist you in preparing your specifications. Also, if you wish, our Contract Department will handle the entire coating job for you, doing the work right at the job site. Write for full information.

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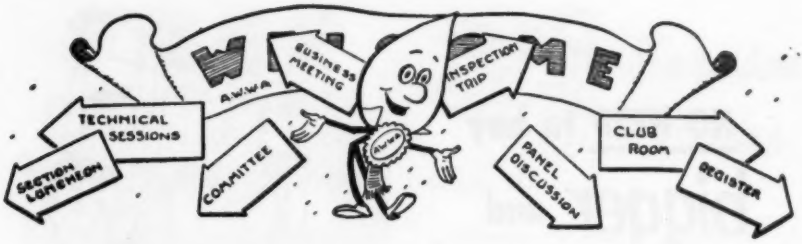


Section Meeting Reports

Nebraska Section: The Nebraska Section, now four years old, held its Annual Meeting at the Cornhusker Hotel in Lincoln on Apr. 17–18. The program subjects ranged from procurement of materials and retirement of utility employees under social security to minimum standards for water distribution systems and operation of municipal swimming pools by the utilities.

As has been the custom since the formation of the section, the meeting was held jointly with the Utilities Section of the League of Nebraska Municipalities. Also, as has been true in the brief existence of the Nebraska Section, this combined meeting was a great success. The large percentage of overlapping membership in the two groups creates a bond of common interest and strength, which is peculiar to Nebraska and which is particularly advantageous to the operations of both organizations.

The nontechnical portion of the meeting was highlighted by an excellent address by AWWA President A. E. Berry at the annual banquet. Those in attendance at the banquet also witnessed a very fine sound movie entitled "Dust or Destiny."

E. Bruce Meier
Secretary-Treasurer

California Section: The fifth spring conference of the California Section was held at the Ahwahnee Hotel in Yosemite Valley on April 18, 1952. The meeting was presided over by Chairman Joseph D. DeCosta, manager of the Engineering Div. of the East Bay Municipal Utility Dist. The total registration was 355.

The welcoming address was given by Dr. Carl Russell, park superintendent. He stressed the importance of the park as the headwaters of the two large stream systems of the Tuolumne and Merced Rivers. Both of these streams not only contribute to the many natural beauties in the park but ultimately provide water supply and power development for all purposes and thus are large factors in the economy of California. Carleton Smith, park engineer, then reviewed the water system in the park. There

(*Continued on page 88*)

How's this for putting brains to work?

For more than 70 years, Cook Well Strainer Company, Inc., of Lawrenceburg, Indiana, has been making well strainers. For many of these years slotted seamless brass tubes, up to 12″ in diameter, proved wholly adequate. But the insistent demand for more and more water called for deeper wells with larger diameters—and strainers to meet the new needs.

The basic features of the famously successful tube strainer—direct inlet; self-cleaning slot, larger inside than outside; one metal; strength; rigidity—would have to be duplicated in larger diameters.

Why not a wire-wound strainer with automatically made *mechanical* bonds? Indeed, why not? The illustrations on this page show the practical application of this ingenious idea. Cook Wire-Wound Well Strainers are now made in sizes up to 40″ inside diameter—at high speeds, with slot widths readily variable, and lengths limited only by handling facilities.

Two ANACONDA Metals, Red Brass-24 and Everdur*-1010 Copper-Silicon Alloy, are outstanding for this application. Both machine readily, withstand upsetting, contribute strength and rigidity, and provide excellent resistance to corrosive ground waters. The American Brass Company, General Offices, Waterbury 20, Connecticut.

B292-B

*Reg. U. S. Pat. Off.

16″ diameter, 35-foot-long Cook Well Strainer made of Everdur being installed at Fort Knox, Kentucky.

As the supporting skeleton of bars revolves in this winding machine, each bar is machine-notched ahead of the spirally wound wire (see circle illustration). This wire is a specially drawn AnacondA Shape of modified keystone cross-section. A circular form tool then displaces the metal on one side of the V-groove into the dovetail section of the wire, locking it securely.

the name to remember

ANACONDA®

COPPER, BRASS & BRONZE

(*Continued from page 86*)

are 30 separate water systems serving the many areas and spots ranging from single drinking fountains to large water systems.

The first technical paper on the program was on "Underground Water Problems in California" by Kenneth Wright, attorney from Los Angeles (*see* this issue, p. 648).

W. Coburn Cook, attorney from Turlock, then presented a paper on "Federal Claims to California Water." He referred to the Fallbrook Case and other national encroachments upon California's water supplies.

Gerald E. Arnold, now director of the Water Resources Div. of NPA, Washington, D.C., reviewed the operations of his office and the methods by which applications for materials are processed. He mentioned that materials for drainage and flood control have been added to the water and sewage projects already within his jurisdiction.

A paper on "Sizing of Service, Meter and House Piping" by S. M. Tatarian, assistant superintendent, City Distribution, San Francisco Water Dept., was read by Oscar Goldman.

A paper on "Presenting a Corrosion Control Program to Management" written by C. W. Shupp, superintendent of distribution, Northern Div., Southern California Gas Co., was presented by Mr. Nielson of the same company. The paper reviewed the causes of corrosion and the methods in use for its control, stressing cathodic protection.

Morris S. Jones, national director for the section and chief engineer and general manager of the Pasadena Water Dept., reported on the annual meeting of the AWWA Board of Directors. Of particular note was the reaffirmation of the policy on fluoridation as previously adopted.

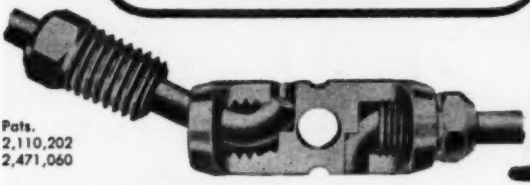
"Water Quality Requirements for Industrial Purposes" were reviewed by Richard H. Gilman, project engineer, Sanitary Engineering Research, California Inst. of Technology. The single quality which is most desirable for all industries is constancy of quality. Water characteristics desirable for concrete, laundries, photographic processes, ice making, canning and food processing, and brewing were discussed. The institute is still engaged in making an extensive study of quality water requirements for industrial purposes and will publish a complete work on its findings.

The banquet was held in the Ahwahnee Hotel. Entertainment under K. A. Keirn was obtained from Modesto. Following the entertainment the group viewed the firefall.

The Executive Committee met on Saturday to transact the section's business, and passed a resolution to the effect that the laws of the state of California on water and power rights be binding and be followed by all agencies—federal, state, public and private—in the development and use of water and power within the state of California.

JOHN C. LUTHIN
Secretary-Treasurer

"I NEVER CONNECT IN THE WRONG HOLE- with FLEXICROME SEWER-ROD COUPLINGS!"



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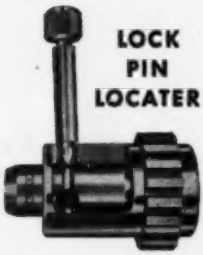
This improved coupling for HIGH SPEED POWER TURNING MACHINES never assembles in the wrong (lock pin) hole, making it necessary to uncouple to use a lock pin. Saves time and money. CLICK, SNAP — IT'S HOME. "FLEXICROME" ROD —made exclusively for Flexible — is used exclusively. They are intechangeable with all "OLD STYLE" Flexible Rods.

"OLD STYLE" Rods and Couplings can still be furnished to cities that still turn their rods by hand (the slow, expensive way). Expect as good results as you had 15 YEARS AGO.



Just move coupling in or out of the ratchet or power drive shaft—pressing pin down till it clicks. Then turn right or left for hole.

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Coming Meetings

September 3–5—New York Section at Saranac Inn, Upper Saranac Lake. Secretary, R. K. Blanchard, Vice-Pres. & Engr., Neptune Meter Co., 50 W. 50th St., New York 20, N.Y.

10–12—Minnesota Section in Sioux Falls, S.D. Secretary, L. N. Thompson, Gen. Mgr., Water Dept., St. Paul 2, Minn.

15–17—Kentucky-Tennessee Section at Andrew Johnson Hotel, Knoxville. Secretary, R. P. Farrell, Director, Div. of San. Eng., Tenn. Dept. of Pub. Health, 420 6th Ave., N., Nashville 3, Tenn.

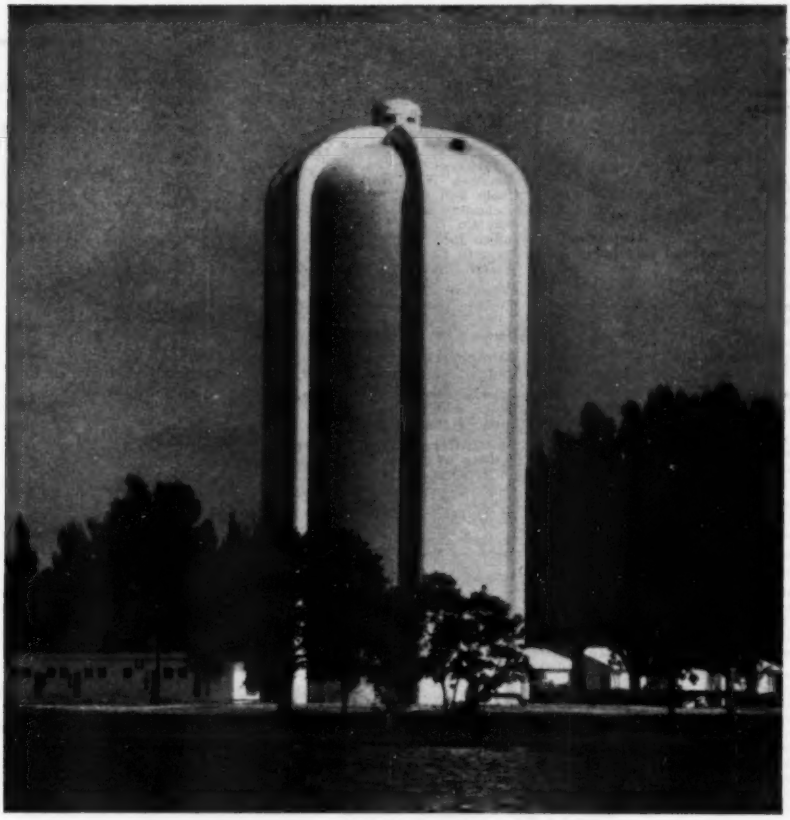
16–17—Rocky Mountain Section at Frontier Hotel, Cheyenne. Secretary, George J. Turre, San. Engr., Board of Water Comrs., Box 600, Denver, Colo.

16–18—Wisconsin Section at Hotel Loraine, Madison. Secretary, Leon A. Smith, Supt., Water & Sewerage, City Hall, Madison 3, Wis.

18–19—Ohio Section at Netherland Plaza Hotel, Cincinnati. Secretary, M. E. Druley, Dist. Mgr., Dayton Power & Light Co., Wilmington, Ohio.

21–23—Missouri Section at Hotel Governor, Jefferson City. Secretary, Warren A. Kramer, Div. of Health, State Office Bldg., Jefferson City, Mo.

24–26—Michigan Section at Post Tavern, Battle Creek. Secretary, T. L. Vander Velde, Chief, Section of Water Supply, State Dept. of Health, Lansing, Mich.



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This 1,000,000-gal. Horton steel standpipe is an all welded steel structure which we built at Clearwater, Fla. It is 43-ft. in diam. and 95-ft. to the high water line.

A reserve supply of water of this kind helps to smooth out pressure fluctuations due to varying demands; bolsters pressure in areas remote from pumping station; relieves the pumps of peak loads by temporarily storing water pumped during slack periods and often justifies lower fire insurance premiums. Write our nearest office for information on standpipes or elevated water tanks.

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(See Prof. Services, pp. 25–29)

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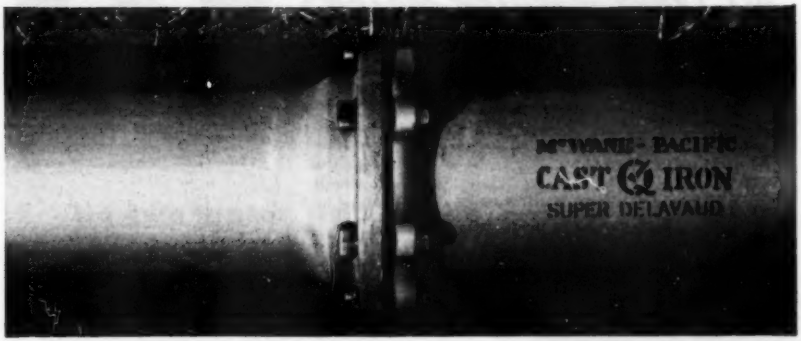

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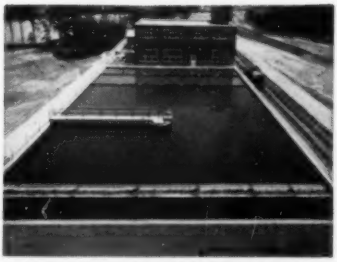

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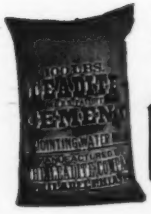

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